

**“EVALUATION OF SEQUENTIAL APPLICATION OF
INSECTICIDES AGAINST POD BORER COMPLEX OF
PIGEONPEA”**

By

SUDAM GANESH WAGH

B.Sc. (Agri.)

**MASTER OF SCIENCE
(Agriculture)
IN
AGRICULTURAL ENTOMOLOGY**

**DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
COLLEGE OF AGRICULTURE, BADNAPUR
VASANTRAO NAIK MARATHWADA KRISHI VIDYAPEETH,
PARBHANI- 431 402 (M.S.) (INDIA)**

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DISSERTATION

Submitted to

***The Vasant Rao Naik Marathwada Krishi Vidyapeeth, Parbhani
in partial fulfillment of the requirements for the Degree of***

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IN

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**DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
COLLEGE OF AGRICULTURE, BADANPUR
VASANTRAO NAIK MARATHWADA KRISHI
VIDYAPEETH, PARBHANI
2017**

CANDIDATE'S DECLARATION

I

hereby

declare that the

dissertation or part thereof,

has not been previously submitted

by me for a degree of any

University.

Place: Badnapur

Date: / /2017

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CERTIFICATE – I

This is to certify that the dissertation entitled “**EVALUATION OF SEQUENTIAL APPLICATION OF INSECTICIDES AGAINST POD BORER COMPLEX OF PIGEONPEA**” submitted by Mr. **WAGH SUDAM GANESH** to the Vasantao Naik Marathwada Krishi Vidyapeeth, Parbhani in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **AGRICULTURAL ENTOMOLOGY** is record of original and *bonafide* research work carried out by him under my guidance and supervision. It is of sufficiently high standard to warrant its presentation for the award of the said degree.

I also certify that the dissertation or part thereof has not been previously submitted by him for a degree of any University.

Place: Badnapur

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CERTIFICATE – II

This is to certify that the dissertation entitled “**EVALUATION OF SEQUENTIAL APPLICATION OF INSECTICIDES AGAINST POD BORER COMPLEX OF PIGEONPEA**” submitted by Mr. **WAGH SUDAM GANESH** to the Vasantao Naik Marathwada Krishi Vidyapeeth, Parbhani in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **AGRICULTURAL ENTOMOLOGY** has been approved by the student’s advisory committee after viva-voce examination in collaboration with the external examiner.

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ABBREVIATIONS

@	=	at the rate of
a.i.	=	active ingredient
cm	=	centimeter(s)
m	=	meter(s)
<i>et al.</i>	=	and other
etc.	=	etceteras
EC	=	Emulsifiable concentration
SC	=	Suspension concentration
SP	=	Soluble powder
DAS	=	Days after spraying
WP	=	Wettable powder
Fig.	=	Figure
g	=	gram (s)
ha	=	hectare
kg	=	kilogram (s)
q	=	quintal
L	=	liter(s)
ml	=	milliliter(s)
%	=	per cent
viz.,	=	videlicet (namely)
No.	=	Number
N	=	North
/	=	per
Rs.	=	Rupees
h	=	hours
>	=	greater than
Ltd.	=	Limited
SE	=	Standard error
CD	=	Critical difference
DBS	=	Days before spray
pp	=	pages
MRL	=	Meter row length
SMW	=	Standard meteorological week
WDG	=	Weighable dust granul

CHAPTER – I

INTRODUCTION

The pigeonpea (*Cajanus cajan*, (L.) Millsp.) is thought to have originated in India. Pigeonpea is the second important pulse crop of India after chickpea. Legumes occupy most important position in the diet of the people living in the subcontinent and have its own unique position in Indian agriculture. Out of the grain legume pigeonpea is an important pulse crop cultivated throughout India.

Pigeonpea commonly known as arhar, red gram or tur is one of the major grain legumes in the semi-arid tropics. Pulse crop provide protein rich diet to people. They are consumed in the form of split pulse or dal, for livestock it provides not only nutritive fodder but also valuable feed. While dried stalks are used as fuel and basket making.

It is hardy, widely adaptable and tolerant of temperature as high as 35⁰ C. It can be killed by heavy frost. An average rainfall between 600 and 1000 mm is most suitable. It gives economic yield of seeds in areas where rainfall average about 400 mm annually. Although, it cannot withstand water logging it can be grown in a wide range of soils, as it tolerates low fertility. Some cultivars are tolerant of salinity and aluminium. A pH range of 4.5 - 8.4 is tolerated. Pigeonpea seed is eaten fresh (green) primarily in Africa and the Caribbean and dehulled (dhal) in South Asia (Rangarao *et al.*, 1999).

India, pigeonpea is cultivated in 3.79 million hectares with an annual production of 2.56 million tones and average productivity of 673 kg/ha. Major pigeonpea growing states in India include Uttar Pradesh, Maharashtra, Madhya Pradesh, Gujarat and Karnataka. In Maharashtra, the area under pigeonpea was 12.36 lakh hectares with production 4.44 lakh tones and average productivity 359 kg/ha. In Marathwada under pigeonpea crop was 5.28 lakh hectares with productivity of 1.10 lakh tones and average productivity of 208 kg/ha during 2015-16. (Anonymous, 2015).

India is the largest producer and consumer of pulses in the world. At present, it accounts for 33% of the world area and 22% of world production. Pigeonpea is the second largest pulse crop in the country occupying 5.21 million ha with 4.23 million tonnes of production with the productivity of 826 kg/ha (2nd Advance Estimate 2016-17). (Anonymous, 2016)

In Maharashtra, Area under Pigeonpea was 15.33 lakh ha and production 11.70 lakh tones with the productivity of 764 kg/ha during year 2016-17(2nd Advance Estimate 2016-17). When we compare the figure with current year with 2015-16, the area, production and productivity of pigeonpea has been increased by 19.37%, 62.05% and 53.01% respectively. (Anonymous, 2016)

Productivity of pigeonpea has remained static over the past several decades because of many reasons; out of which is heavy damage by insect pests is one of them. More than 200 insects species belonging to 8 orders and 61 families have been found to attack the pigeonpea crop, out of which pod borer *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) is most devastating pest in the semi-arid tropics (SAT) worldwide (Sharma et al., 2008) and causes significant losses in grain yield, and in severe cases may cause complete crop loss. Over the past decade, three outbreaks of this pest were recorded, 1997 in Gulbarga which is known as the pulses bowl of Karnataka. *Helicoverpa armigera* (Hubner) is reported to cause 50 to 60 per cent grain loss in pigeonpea. During 1997-98, pigeonpea suffered a complete loss due to *Helicoverpa armigera*. On an average, pod borer caused 90-100 per cent yield loss in 1992-93 and 1997-98. Annual yield losses due to this pest have been estimated to be over US\$2 billion in the semi-arid tropics and 300-400 million per annum in India alone.

Pigeonpea is the preferred host for feeding followed by chick pea, okra, pea, cotton and tomato (Ramnath *et al.*, 1992). It is rich source of protein ranging from 17-25 per cent. It is also a good source of minerals like calcium and phosphorus also contain vitamin and amino acid. Pigeonpea is an important component of farming system as it fixes atmospheric nitrogen in the soil and improves soil fertility. It is deep root crop and helps to check erosion of soil and also act as wind breaks.

It is attacked by several insect pests from seedling to pod harvesting. Of these, pod borers cause damage to the crop from flowering to maturity stage thereby it accounts to an yield loss of more than 1000 dollars every year (Sharma, 2001), causes complete crop loss. Important pest infecting pigeonpea crop are pod borer, *Helicoverpa armigera* (Hubner), plume moth, *Exelastis atomosa* (Walsingham), pod fly, *Melanogromyza obtusa* (Malloch), spotted pod borer, *Maruca vitrata* (Fabricius), and bruchids. Bruchids which is store grain pest but infection start from field at harvesting stage.

Out of these *Helicoverpa armigera*, *Exelastis atomosa*, *Melanogromyza obtusa* and *Maruca vitrata* are the key pests. To meet the demand of increasing population the present area and production is inadequate. There is a great scope to increase the production by controlling the key pests.

The extent of damage caused by *H. armigera* and *M. obtusa* in pigeonpea during *kharif* 1984 and 1985 in Hissar, Haryana state was observed to be 13.6 and 13.7 per cent to pods and 5.3 and 5.3 per cent to grains damage, respectively (Yadav and Chaudhary, 1993).

The early, medium and late maturing cultivars of pigeonpea were reported to be damaged by *M. obtusa* and *H. armigera* to the tune of 29.55 to 55.63, 20.95 to 57.00 and 32.92 to 56.56 per cent, respectively (Shrivastava *et al.*, 1993). Pigeonpea pod damage due to insects varied from 7.6 to 31 per cent. *G. critica* was the most important insect followed by *H. armigera*, *Maruca testulalis* and *E. atomosa* (Lal *et al.*, 1997). Bhuvanewari and Balagurunathan (2002) reported 27.00 and 17.3 per cent pigeonpea pod damage due to *H. armigera* during 2000-01 and 2001-02.

Management of pod borer relies heavily on insecticides, often to the exclusion of other methods of management. A number of insecticides have been found reported to be effective for controlling pod borer on pigeonpea. Exploring new insecticides with lesser residues and lower environmental threat has become imperative. In recent years, newer compounds with novel modes of action are being evolved to check infestation by this insect pest. The present study is aimed to evaluate the efficacy of certain new insecticides against the pod borer in pigeonpea ecosystem. In view of the importance of this crop and immense damage potential by *H. armigera*, which has developed resistance to insecticides have the eco-friendly management of this pest the present investigations have been carried out with the following objectives.

Objectives:

- 1: To evaluate the sequential application of insecticides against pod borer complex of pigeon pea.
- 2: To study the bio-safety of different insecticides against natural enemies.
- 3: To work out the yield and incremental cost benefit ratio.

CHAPTER - II

REVIEW OF LITERATURE

Keeping in view the objectives of the research work, the literature was reviewed as regards to evaluate the sequential application of insecticides against pod borer complex of pigeon pea under field conditions.

Pigeonpea is severely attacked by different lepidopterous insect-pests, viz., *Helicoverpa armigera*, *Exelastis atomosa*, *Maruca vitrata* and *Melanagromyza obtusa*. In order to plan the pest control strategies, in the present study sequential application of insecticides against pod borer complex of pigeon pea.

The literature pertaining to predetermined aspects such as population dynamics of pests infesting pulse crops with major emphasis to pigeonpea are presented under following headings in this chapter.

2.1. To evaluate the sequential application of insecticides against pod borer complex of pigeon pea.

Sinha *et al.*, (1977) revealed that monocrotophos (0.5 kg a.i./ha) against tur plume moth and quinalphos (0.6 kg a.i./ha), dimethoate (0.5 kg a.i./ha) and endosulfan (0.8 kg a.i./ha) against tur pod fly were very effective and minimum percentage of pod damage was observed in the plots treated with dimethoate (0.5 kg a.i./ha), quinalphos (0.6 kg a.i./ha) and endosulfan (0.8 kg a.i./ha) due to pod fly on early and late varieties of redgram. Similarly the percent loss of grain was significantly lower in these treatments as compared to control (54.5 %).

Khan and Narayanappa (1993) conducted studies to determine the efficacy of acephate 0.07 per cent, endosulfan 0.07 per cent, quinalphos 0.05 per cent, fenvalerate 0.01 per cent and monocrotophos 0.04 per cent for the control of *H. armigera* on pigeonpea. Fenvalerate was the most effective insecticide, followed by endosulfan, monocrotophos, quinalphos and acephate.

Srivastava and Singh (1994) tested some insecticides against pod fly, *M. obtusa* and pod bug, *Clavigralla gibbosa* on long duration *Kharif* pigeonpea. Dimethoate 30 EC (0.04 %) sprays at weekly intervals, starting from the pod formation stage was found to be superior over all other treatments. This treatment also resulted in the highest yield. Monocrotophos 36 SL (0.04 %) and BHC 10 % (20

kg/ha) applied at weekly intervals also showed significantly less pod damage as compared to control plots.

Sahoo and Senapati (2000) study, revealed that the superiority of endosulfan 35% EC followed by acephate 75% SP and triazophos 40% EC each @0.5kg a.i./ha resulting in damage of pods (9.07-12.99%), seeds (5.93-7.30%) and extent of seed loss (4.902-6.87%) at lower levels in comparison to other test compounds and untreated control (pod damage 15.18-59.41%, seed damage 9.16-32.46% and yield loss 7.53-27.08%). The cost: benefit analysis indicated the highest monetary benefit from endosulfan followed by azadiractin, acephate and triazophos treatments. For each one rupee spent, endosulfan gave the profit of Rs. 4.70, as against Rs. 2.28, Rs. 1.83, Rs. 1.00, Rs. 0.74, Rs. 0.43 and Rs. 0.12 in azadiractin, acephate, triazophos, ginger + chilli extract (GCE), neem seed kernel extract (NSKE) and ethofenprox treatments, respectively.

Chaudhary *et al.*, (2003) studied the efficacy of insecticides like acephate, triazophos, chlorpyrifos, profenophos they were tested consecutively for 3 years against gram pod borer (*H.armigera* Hub.) in pigeonpea revealed that on the basis of per-cent pod damage, grain yield, avoidable yield loss and net grain in terms of monetary profit, the application of profenophos @1500ml/ha was found most effective with minimum per-cent pod damage (8.09) maximum grain yield (12.88 q/ha), maximum avoidable loss in yield (43.24%) and maximum net grain (Rs.6348/ha).

Singh and Yadav (2005) Study conducted by on pod borer viz., *H. armigera* and *E. atomosa* reported that they are the major pests causing economic damage to the pigeonpea crop. Keeping in view, the economic importance of both the pests, an investigation was laid out to assess the bioefficacy of two modern insecticidal molecules i.e., indoxacarb, spinosad, two *Bacillus thuringiensis* based bioinsecticides viz., biolep, halt and their judicious combination during *kharif* 2004-05. The studies revealed that combination of full dose of indoxacarb with halt (T₆) was most effective treatment in reducing pod damage (9.00%), grain damage (6.48%) and weight loss (5.83%) in pigeonpea crop during both the years.

An experiment was conducted to evaluate the efficacy of some newer insecticides against pod borers in pigeonpea at Coimbatore. The minimum percent

pod damage (10.00%) due to *H. armigera* was recorded in indoxacarb 14.5 SC @ 60g.a.i/ha with the grain yield of 1066.2 Kg/ha (Anonymous, 2005).

Razaq *et al.*, (2005) revealed that newly introduced emamectin benzoate was the most effective against *H. armigera* with a larval mortality of 73.50 per-cent. Spinosad and chlorpyriphos showed similar results but lower mortality than indoxacarb (71.2%). However, pyrethroids were found to be the least effective.

Suganthi *et al.*, (2006) the bioefficacy of pyridalyl against pod borer, *Helicoverpa armigera* (Hub.) on pigeonpea was evaluated in farmers holding at Thondamuthur near Coimbtore in Tamilnadu during January-February, 2005 and November-December, 2005. Paridaly 10 EC was tested @ 50, 70 and 100 g a.i./ha. Monocrotophos 36 WSC @ 360 g a.i./ha and indoxacarb 14.5 SC @ 75 g a.i./ha were kept as standard check for comparison. Pyridalyl @ 75 and 100 g a.i./ha and indoxacarb @ 75 g a.i./ha were on par with each other with regard to pod damage and pod yield but superior to monocrotophos @ 360 g a.i./ha.

Raghvani and Poshia (2006) carried out field testing of novaluron at 50, 75 and 100 g a.i./ha, emamectin benzoate 8, 9 and 11 g a.i./ha, spinosad 60 g a.i./ha, profenofos 750 g a.i./ha, methomyl 250 g a.i./ha, indoxacarb 72.5 g a.i./ha and endosulfan 350 g a.i./ha bioefficacy against chickpea pod borer, *Helicoverpa armigera* (Hubner) at Pulses Research Station, Junagadh Agricultural University, Junagadh (Gujarat) during 2004-05 *rabi* season. Novaluron 100 g a.i./ha registered lower pod damage (4.83%) followed by emamectin benzoate 11 g a.i./ha (5.13%) and spinosad 60 g a.i./ha (6.83%). Pod damage for the other insecticides varied from 7.16 to 8.62 per cent. All the insecticidal treatments exhibited higher grain yield over control. All the insecticides were at par with each other.

Sidde Gowda *et al.*, (2006) tested efficacy of spinosad 35 SC and indoxacarb 14.5 SC for two years on gram pod borer, *Helicoverpa armigera* (Hubner) at two dosages in comparison with profenophos 50 EC (750 g a.i./ha) and chloripyriphos 20 EC @ 500 g a.i./ha. Spinosad 45 SC (22.5 g a.i./ha) and indoxacarb 14.5 SC g a.i./ha recorded significantly lower pod damage (6.68% and 7.74%) and higher grain yield (10.30 and 9.17 q/ha) compared to profenophos 50 EC @ 750 g a.i./ha and chloropyriphos 20 EC @ 500 g a.i./ha.

Singh and Verma (2006) tested novaluron in field for its bio efficacy against chickpea pod borer, *H armigera* at Agricultural Research Station, Sriganganagar

during 2003-04 and 2004-05 crop seasons in comparison with newer molecules viz. Emamectin benzoate, Indoxacarb and Spinosad. Novaluron, Emamectin benzoate and Spinosad treatments recorded lower pod damage and higher grain yield respectively. Besides, no adverse effects on crop as well as predators and parasites have been observed.

Shrinivasan and Durairaj (2007) conducted two field experiments during 2003 and 2004 to evaluate the bioefficacy of certain newer insecticides against gram pod borer, *H. armigera* and pod fly, *Melanagromyza obtusa* on pigeonpea. Experimental results showed that the least *Helicoverpa* larval population of 2.0/plant was recorded on spinosad 45 SC (73 g a.i./ha) treatment followed by indoxacarb 14.8 SC (2.4/plant) as against a maximum population of 6.7/plant in the untreated check. The pod damage due to *H. armigera* infestation was the least (9.4%) in bifenthrin 10 EC (80 g a.i./ha) treated plots as against a maximum pod damage of 56.3 per cent in the untreated control. However, the grain damage due to pod fly was the lowest in monocrotophos 36 WSC @ 270 g a.i./ha and was followed by bifenthrin 10 EC (25.6%). The untreated plot recorded maximum damage of 53.7%. Highest grain was recorded in bifenthrin treated plots (925.6 kg/ha) followed indoxacarb (864.0 kg/ha) and spinosad 45 SC @ 73 g a.i./ha (841.1 kg/ha) as against the minimum yield of 432.7 kg/ha in the untreated control.

Ameta and Kumar (2008) field experiments on relative efficacy of flubendiamide, an insecticide of phthalic acid diamide group, at the doses of 36 and 48 and 60 g a.i./ha (75, 100, 125 ml/ha) along with indoxacarb @ 75 g a.i./ha (500 ml/ha) and spinosad @ 90 g a.i./ha (200 ml/ha) against *H. armigera* and *Spodoptera litura* (Fab.) in chilli was conducted during 2005-06 and 2006-07 at Rajasthan College of Agriculture, Udaipur. Three sprays of flubendiamide, indoxacarb and spinosad were significantly superior to untreated control in reducing *H. armigera* and *S. litura* in chilli. Among different treatments, flubendiamide @ 60 g a.i./ha (125 ml/ha) caused significantly higher reduction in the population of both the species of insect pest and also recorded the highest marketable fruit of chilli.

Sunitha *et al.*, (2008) observed the relative efficacy of newer insecticides with conventional insecticides, bio insecticides and botanicals against 3rd instar larvae of *Maruca vitrata* and found that indoxacarb and spinosad were highly effective in

reducing the larval population and were at par with conventional insecticide endosulfan.

Tamboli and Lolage (2008) depicted spinosad 45 SC @ 90 g a.i. per ha as the most potent insecticide in reducing the larval population (0.29 larvae/plant), pod damage (5.62%), grain damage (22.85%) and producing highest grain yield of 1681kg per ha, followed by flubendiamide 20 WDG @ 50 g a.i. per ha and novaluron 10EC @ 75 g a.i. per ha.

Dodia *et al.*, (2009) conducted experiment on Efficacy of insecticides against gram pod borer, *Helicoverpa armigera* Hardwick, infesting pigeonpea and they reported that the results on pod borer damage at harvest revealed that all the treatments were significantly superior over untreated control year wise as well as in pooled analysis. Looking to the efficacy of different dose among chemicals, it was increased with the increase of concentration. Lower dose of spinosad (56 g a.i./ ha) and emamectin benzoate (8 g a. i./ ha) were found less effective against their higher doses (73 g a.i./ ha and 11 g a.i./ha, respectively). Among the treatments, flubendiamide 20 WDG 50 g a. i./ ha was found most effective with 5.98 per cent damage of the pest, which stood at par with emamectin benzoate 5 WSG 11 g a.i./ ha (6.53%) and spinosad 45 SC 73 g a.i./ ha (7.35%). Rest insecticides were found inferior, though placed significantly superior over control (17.06%).

Jadhav *et al.*, (2009) Evaluated the efficacy of certain newer insecticides alone and in combination against bollworm complex of cotton during *kharif* 2006-07. The treatment acetamiprid 2% + indoxacarb 15% @ 20 and 150 g a.i./ha was the superior treatment in controlling per cent infestation in fruiting bodies (squares, flowers and green bolls) followed by acetamiprid 2% + indoxacarb 15% @ 12 and 90 g a.i./ha and acetamiprid 2% + indoxacarb 15% @ 10 and 75 g a.i./ha. Among the sole insecticides, indoxacarb 14.5 SC 15% @ 75 g a.i./ha was found to be most superior for minimizing per cent infestation in fruiting bodies and per cent infestation of bollworm in locule. The lowest per cent infestation in locule at harvest due to bollworms was observed in combination treatments acetamiprid 2% + indoxacarb 15% @ 20 and 150 g a.i./ha. Highest seed cotton yield was obtained from the treatment acetamiprid 2% + indoxacarb 15% @ 20 and 150 g a.i./ha.(12.45 q/ha). Among sole insecticides, indoxacarb 14.5 SC 15% @ 75 g a.i./ha.(8.21q/ha) was found superior.

Babariya *et al.*, (2010) reported in the result of investigation of chemical control of gram pod borer (*H. armigera* Hub.). Infecting pigeonpea indicated that among the different insecticides tested indoxacarb 0.0075% gave the highest percent mortality of the pest followed by spinosad 0.009%, profenophos + cypermethrin 0.044% and endosulfan 0.07%, indoxacarb 0.0075% recorded significantly highest grain yield.

Deshmukh *et al.*, (2010) in a field experiment, conducted to determine the efficacy of different insecticides against *Helicoverpa armigera* (Hubner) infecting chickpea at Junagadh Agricultural University campus, Junagadh during *Rabi* season of 2008-09. The results revealed that flubendiamide 0.007 per cent, indoxacarb 0.0075 per cent, spinosad 0.009 per cent and emamectin benzoate 0.0015 per cent were found the most effective in reducing the *H. armigera* population and pod damage of chickpea. The highest yield was also recorded in the treatment of flubendiamide 0.007 per cent (1850 kg/ha) followed by indoxacarb 0.0075 per cent (1805 kg/ha), spinosad 0.009 per cent (1760 kg/ha) and emamectin benzoate 0.0015 per cent (1665 kg/ha). The highest cost benefit ratio was obtained in the treatment of indoxacarb 0.0075 per cent (1:7.08), followed by flubendiamide 0.007 per cent (1:6.10) and spinosad 0.009 per cent (1:5.24). Thus, considering the cost benefit ratio, any one of these insecticides spray at 50 per cent flowering and second at 15 days after first spray can be suggested for the effective control of gram pod borer on chickpea.

Pappu *et al.*, (2010) the present investigation was conducted to evaluate the comparative performance of some newer and commonly used insecticides against the insect-pest complex of short duration pigeonpea in *kharif* 2007. During the year of experimentation, the three application of Syn-A 15397 ZC 15% @ 22.5 g a.i./ha, Syn-A 15397 ZC 15% @ 30 g a.i./ha and Syn-A 15397 ZC 15% @ 37.5 g a.i./ha gave the best protection against pod fly. Syn-A 15397 ZC 15% @ 30 g a.i./ha gave the good control in per-cent grain damage by pod bug. Both the treatment of Syn-A 15397 ZC 15% @ 30 g a.i./ha and Indoxacarb 14.5% SC @ 60 g. a.i./ha gave better control of lepidopterous borers. The highest grain yield (670 kg/ha) was recorded from the plots treated with Syn-A 15397 ZC 15% @ 37.5 g a.i./ha.

Ameta *et al.*, (2010 a) the experiment on efficacy of Flubendiamide 480 SC at the rate of 37.5, 50, 75 and 100 ml/ha, along with Quinalphos 25 EC @ 1000ml, Acephate 75 SP @ 625 ml and Endosulfan 35 EC @ 1000 ml/ha against *H. armigera*

in chickpea was conducted at R.C.A. Udaipur during *rabi* 2008-09 and 2009-10. Among all the treatments Flubendiamide 480 SC at the rate of 100 ml/ha, was found significantly superior to all treatments and it caused highest reduction in the larval population of pod borer. It was followed by Flubendiamide 480 SC at the rate of 75 ml/ha. Flubendiamide 480 SC at 100 ml/ha recorded the significantly highest yield of 17.19 and 18.06 q/ha during *rabi* 2008-09 and 2009-10, respectively. It was at par and followed by Flubendiamide 480 SC at 75 ml/ha which yielded 16.36 and 16.94 q/ha as against 10.41 and 9.93 q/ha in control during *Rabi* 2008-09 and 2009-10, respectively.

Ankali *et al.*, (2011) conducted experiment on Study of relative toxicity of synthetic insecticides and biopesticides to *Maruca vitrata* on pigeonpea. The studies revealed that dichlorvos was highly toxic followed by acephate and spinosin at 1 and 3 DAT further showing cent per cent mortality at 7 DAT. The performance of *Bacillus thuringiensis* and NSKE was poor initially at 1 and 3 DAT later exhibiting more than 70% mortality at 7 DAT.

Khalid and Prasad (2011) in the field experiments conducted at Regional Agricultural Research Station, Lam, Guntur, Andhra Pradesh on chilli crop during 2001-02 and 2002-03 season to evaluate the efficacy of indoxacarb 15% SC against fruit borers, *Helicoverpa armigera* and *Spodoptera exigua*. In both the seasons indoxacarb @ 60, 55 and 50 g a.i./ha were proved to be the best among the treatments by recording higher mean percent reduction in larval population of *Spodoptera exigua* with lowest per cent fruit damage and recorded higher yields. Indoxacarb @ 60 and 55 g a.i./ha were effective against *Helicoverpa armigera* by recording higher percent reduction in larval population over control. The present results suggest that indoxacarb @ 55 g a.i./ha can be considered as an optimum dose for the management of fruit borers on chillies.

Mishra *et al.*, (2012) conducted experiment on pod fly chemical control of pigeon pea pod borers and pod fly with insecticides. Results showed that imidacloprid and acetamiprid showed minimum pod infestation during two years. Rests of the insecticides were significantly superior over the control plots except dhanuvit. Acetamiprid treated plots also gave better results after imidacloprid followed by dimethoate 25 EC, carbosulfan 25 EC, indoxacarb 14.5 SL and methomyl 40 SP. Maximum grain yield, avoidable losses and additional grain yield (18.51 qha⁻¹, 42.7% & 7.91 qha⁻¹) was also recorded in imidacloprid treated plots over control plots.

Narasimhamurthy and Kewal (2012) conducted experiment on efficacy of some insecticides and biopesticides against pod borer, *Helicoverpa armigera* (Hubner) in long duration pigeonpea during 2009-10 and 2010-11. The results revealed that there was a significant difference in per cent larval reduction in both the years. All the treatments were found significantly superior by giving higher mortality of *Helicoverpa* larvae to the control. The treatment of spinosad 45% sc @ 75 g a.i./ha caused highest mortality (92.52-95.98%) of the pest followed by endosulfan 35 EC 0.07% (83.26-88.20% mortality) and acephate 75 SP @0.15% (83.50-86.25% mortality). The lowest larval reduction recorded in HaNPV @ 500 LE/ha with 50.77 to 54.78% mortality. The pod damage ranged from 8.33% in spinosad 45% SC @ 75 g a. i./ha to 24.27% in HaNPV @ 500 LE/ha. The grain damage ranged from 3.67% in spinosad 45% SC @ 75 g a. i./ha to 11.47% in NSKE-5%. The highest grain yield of 1550 kg/ha was recorded with spinosad 45% SC @ 75g a. i./ha. The cost: benefit ratio was high in the plots treated with endosulfan 0.07% (1: 18.87), followed by acephate 75 SP @0.15 % (1:16.45).

Satpute and Barkhade (2012) in the field evaluation of different doses of rynaxypyr 20 SC against the pod borer complex (*Helicoverpa armigera*, *Melanogromyza obtusa*, *Exelastis atomosa*) of pigeonpea revealed significant differences among the treatments and the higher doses of rynaxypyr 20 SC (30 and 40g a.i./ha) were found most effective in reducing the pest population. As far as the yield of pigeonpea was concerned, the conventional insecticides were found at par with the higher doses of rynaxypyr 20 SC.

Singh (2012) reported that among the nine newer insecticide molecules evaluated against pod borers of pigeonpea, indoxacarb treated plots found lowest pod damage (1.30%). It was at par with profenophos (1.85%) emamectin benzoate (2.00%) and thiodicarb (2.03%) treated plots. The highest grain yield was recorded with indoxacarb (2291 kg/ha) while the lowest grain yield was with flubendiamide (1875 kg/ha).

Sreekanth *et al.*, (2013) conducted experiment on bio-efficacy and economics of certain new insecticides against gram pod borer, *Helicoverpa armigera* (Hubner) infesting pigeonpea (*Cajanus cajan* L.) at Regional Agricultural Research Station, Lam, Guntur, Andhra Pradesh. It was revealed that the number of *Helicoverpa* larvae per plant were lowest in plots treated with chlorantraniliprole 20 SC (0.43),

flubendiamide 480 SC (0.59) and spinosad 45 SC (0.85) as against untreated control plot (4.17) with 89.7, 85.9 and 79.6 per cent larval reduction over control, respectively. Pod damage due to pod borer, *Helicoverpa* was lowest in plots treated with flubendiamide (1.16%), chlorantraniliprole (1.26%) and spinosad (1.92%) with 88.7, 87.7 and 81.2 per cent reduction over control respectively. The untreated plot has recorded maximum pod damage of 10.22%.

Wadaskar *et al.*, (2013) conducted experiment on field efficacy of newer insecticides against pod borer complex of pigeonpea and they reported that the reduction of *H. armigera* larval population, 7 and 14 days after the treatment, revealed superiority of flubendiamide 20 WDG @ 0.5 g /l, which resulted in reduction to the extent of 96.1 and 95.4 per cent, over control, respectively. flubendiamide was also efficacious against plume moth larvae, 7 days and 14 days application, with 83.9 and 93.3 per cent reduction over control, respectively. The superior treatment effectively restricted the lepidopteran pod borer damage (4.4%), pod damage by pod fly (7.8%) and grain damage by pod fly(6.0%) to minimal, whereas, untreated control plot had 15.9 per cent pod damage due to lepidopteran pod borers, 14.2 per cent pod damage due to pod fly and 11.0 per cent grain damage by pod fly. The treatment with flubendiamide also translated into realization of highest yield of 13.3 q per ha. As against 8.8 q per ha in untreated control.

Srujana and Kewal (2013) Conducted experiment on Effect of newer insecticides against pod fly, *Melanagromyza obtusa* (Malloch) on long duration pigeon pea They reported that, tur pod fly, *Melanagromyza obtusa* was found to be predominant during the year of experimentation and it causes significant economic losses in the grain yield of long duration pigeon pea BAHAR. During the year of experimentation, the three application of thimethoxam 25 WG @ 75 g a.i. /ha., fipronil 25 EC @ 8 g a.i. /ha., thiacloprid 240 SC @ 75 g a.i. /ha., imidacloprid 17.8 SL @ 20 g a.i. /ha., acetamiprid 20 SP @ 20 g a.i. /ha., dimethoate @ 30 g a.i. /ha., were done. First applied at 50% flowering stage, second applied 15 days after first spraying and last 15 days after second spraying gave the best protection against pod fly. The per cent pod damage by pod fly was minimum is thimethoxam 25 WG @ 75 g a.i. /ha treated plot, during the year of investigation. Next to this is fipronil 25 EC @ 8 g a.i. /ha. thimethoxam 25 WG @ 75 g a.i. /ha treated plot gave the lowest per cent grain damage followed by fipronil 25 EC @ 8 g a.i. /ha.

Sreekanth *et al.*, (2014) conducted experiment on efficacy of novel insecticides to control podfly *Melanagromyza obtuse* affecting pigeonpea (*Cajanus cajan* L.) they reported that the pod damage due to podfly was lowest in spinosad 45% SC (10.2%), flubendiamide 480 SC (10.4%), profenophos 50% EC (10.9%) and chlorantraniliprole 20% SC (12.5%) with 76.7, 76.3, 75.1 and 71.5 per cent reduction over control (43.8%) respectively.

An experiment was conducted on evaluation of bioefficacy of some newer insecticides against *M.vitrata* in pigeonpea at Gulbarga. The minimum percent pod damage due to *M.vitrata* was recorded in indoxacarb 15.8 EC (6.09%) as compared to untreated check (21.73%). Whereas maximum grain yield of 906.67 Kg/ha was recorded in dimethoate 30 EC. (Anonymous, 2014).

Adsure and Mohite (2014) conducted experiment on efficacy of newer molecules of insecticides against gram pod borer, *Helicoverpa armigera* (Hub.) on Chickpea they reported efficacy of clothianidin 50 WDG, indoxacarb, flubendiamide 480 SC, fipronil 5 SC, spinosad 45 SC, indoxacarb 14.5 SC, rynaxypyr 20 SC, chorpyriphos 20 EC against the surviving larval population of gram pod borer, *Helicoverpa armigera* (Hub.) on chickpea in the experimental research area of farmers field in Chandre village, Dist -Kolhapur during Rabi season 2009-10. In newer insecticides lowest number of surviving population of larvae was recorded in treatment rynaxypyr 20 SC @ 40 g a.i./ha 0.70 larvae/plant, highest yield recorded 15.00q/ha and lower pod damage recorded 8.10 per cent.

Khorasiya *et al.*, (2014) conducted experiment on Field efficacy of *Helicoverpa armigera* on pigeonpea they reported that the indoxacarb 0.007 per cent, spinosad 0.005 per cent and emamectine benzoate 0.005 per cent were found to be the most effective in reducing the gram pod borer population. Considering the overall efficacy, yield and economics of different insecticides, two sprays of indoxacarb 0.007 per cent, endosulfan 0.07 per cent, cypermethrin 0.006 per cent, novaluron 0.01 per cent can be recommend for effective and economical control of gram pod borer infesting pigeonpea.

Gadhiya *et al.*, (2014) conducted experiment on evaluation of insecticides for the management of *Helicoverpa armigera* (Hubner) Hardwick and *Spodoptera litura* (Fabricius) infesting groundnut. Insecticides used in experiment were emamectin benzoate 5 WG @ 0.002%, thiodicarb 75 WP @ 0.075%, indoxacarb 14.5 SC @

0.007%, spinosad 45 SC @ 0.018%, novaluron 10 EC @ 0.01%, lufeneuron 5 EC @ 0.005%, flubendiamide 480 SC @ 0.014%, chlorantraniliprole 20 SC @ 0.006% and metaflumizone 22 SC @ 0.044%. Two sprays of respective insecticides were applied at 15 days interval. Among nine insecticides, chlorantraniliprole (0.006%), spinosad (0.018%) and emamectin benzoate (0.002%) were noticed higher effective and statistically at par with each other in protecting the groundnut crop from the infestation of both pests. metaflumizone (0.044%) and lufeneuron (0.005%) were noticed poor in checking the incidence of *H. armigera* and *S. litura*. Highest cost benefit ratio 1: 3.3 was observed in chlorantraniliprole (0.006%) followed by indoxacarb treatment.

Yadav and Singh (2014) conducted studies to know the efficacy of some new molecule insecticides (azadirachtin, *Bt*, endosulfan 35% EC, thiodicarb 75% WP, spinosad 45% SC, lambda cyhalothrin 5% EC, indoxacarb 14.5% SC, profenophos 50% EC and acetamiprid 20% SP) against spotted pod borer, *Maruca vitrata* (Geyer) on mungbean. The spinosad 45% SC and indoxacarb 14.5% SC were the most effective treatments and significantly superior to other treatments with 80.7 and 79.2 per cent larval reduction over control. The least effective treatments were acetamiprid 20% SP, followed by azadirachtin with 38.8 and 44.9 per cent reduction in larval population over control. The maximum yield was recorded in treatment indoxacarb 14.5% SC (11.8 q/ha) followed spinosad 45% SC (11.1 q/ha) which were at par with each other. While lowest yield was recorded in azadirachtin (9.7 q/ha).

Umbarkar and Parsana (2014) reported the field efficacy of different insecticides against spotted pod borer, *Maruca vitrata* (Geyer) infesting Green gram. The results revealed that spinosad 0.009 per cent, indoxacarb 0.0075 per cent, profenophos 0.05 per cent and cypermethrin 0.009 per cent were found the most effective in reducing the *M. vitrata* population. The highest yield was recorded in the treatment indoxacarb 0.0075 per cent (1516 kg/ha) with minimum pod damage of 9.58 per cent, followed by spinosad 0.009 per cent (1467 kg/ha), cypermethrin 0.009 per cent (1420 kg/ha) and profenophos 0.05 per cent (1385 kg/ha). The highest cost benefit ratio was obtained in the treatment of cypermethrin 0.009 per cent (1:15.29) followed by profenophos 0.05 per cent (1:12.54).

Patel and Patel (2013) reported bio-efficacy of newer insecticides against pod borer complex of pigeonpea (*Cajanus cajan* (L.) Millspaugh) and it was revealed that Among the various insecticides, chlorantraniliprole @ 30 g a.i./ha was the most

effective insecticide against gram pod borer and blue butterfly, while profenophos 50 EC @ 250 g a.i./ha was the most effective insecticide against tur plume moth. Chlorantraniliprole 18.5 % SC @ 30 g a.i./ha registered the lowest pod damage due to borer and pod fly and recorded the highest yield of pigeonpea.

At Badnapu, application of indoxacarb was superior over all the treatments including control in the management of pod borer (*H. armigera* Hub.) and pod fly. Rest of botanicals also recorded significant reduction in per-cent pod damage and grain damage. The highest yield was recorded by indoxacarb. (Anonymous, 2014)².

At SK Nagar, lowest number of larvae per plant was observed in rynaxipyr. Highest yield (1983 kg/ ha) was in rynaxipyr and there was significant differences amongst insecticide treated plots. (Anonymous, 2014)².

Sambathkumar *et al.*, (2015) conducted experiment on field evaluation of newer insecticide molecules and botanicals against pod borers of red gram and they reported that the least incidence of *Maruca vitrata* was recorded in indoxacarb 15.8 EC @ 75 g a.i./ha (3.1 webbings/10 plants) and chlorantraniliprole 18.5 SC 30 g a.i./ha (3.9 webbings/10 plants). The minimum larval population of *Helicoverpa armigera* was recorded in chlorantraniliprole 18.5 SC @ 30 g a.i./ha (9.5 nos./10 plants) and indoxacarb 15.8 EC @ 73g a.i./ha (10.3 nos./10 plants). Low per cent pod fly grain damage (11.7) was recorded in chlorantraniliprole 18.5 SC @ 30 g a.i./ha with the highest yield of 892.2 kg/ha in indoxacarb 15.8 EC @ 75g a.i./ha.

Sreekanth *et al.*, (2015) conducted experiment on ‘Efficacy of Different Insecticides against Legume Pod Borer, *Maruca vitrata* (Geyer) on Pigeonpea (*Cajanus cajan* L.)’ they reported that the per cent inflorescence damage due to *M. vitrata* larvae was lowest in fipronil (17.8), acetamiprid (17.9) and dimethoate (18.5) as against control (31.2) with 43.0, 42.6 and 40.7 per cent reduction over control respectively. Similarly, pod damage was lowest in fipronil (20.9%), followed by dimethoate (27.6%) with 55.8 and 41.7 per cent reduction over control (47.3%). Highest grain yield was recorded in fipronil treated plots (444.9 kg/ha), followed by thiacloprid (417.0 kg/ha) and dimethoate (395.6 kg/ha) with 47.5, 38.3 and 31.2 per cent increase over control respectively as against the minimum yield of 301.6 kg/ha in the untreated check.

Dabhi *et al.*, (2015) Conducted experiment on Bio-efficacy of indoxacarb 15 EC against pod borer, *Helicoverpa armigera* (Hubner) hardwick infesting pigeonpea. They reported that Emulsifiable concentrate indoxacarb (KN 128 15 EC) when evaluated at different doses for its field bio-efficacy in comparison with endosulfan

0.07 per cent (conventional insecticide) against *H armigera* on pigeonpea during 2003-04 and 2004-05. Different doses of indoxacarb 15 EC (KN 128) found to be more or less dose related. However, the indoxacarb 15 EC@ 50 g.a.i/ha was most effective for the control of pod borer followed by 60 g.a.i/ha. These doses also recorded significant higher grain yield during both the year (1753 and 1652 kg/ha), respectively.

Karmakar and Patra (2015) conducted experiment on Bio-efficacy of some new insecticide molecules against pod borer complex of Red gram. They reported that a Field experiment was conducted at District Seed Farm, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal during the year 2008-09 and 2009-10, evaluate the bio-efficacy of premix formulation of pyridalyl 15% + fenpropathrin 20% EC against pod borer complex of red gram. 'UPAS-120' variety of red gram was sown during *kharif* season in the plot size of 5m x 4m with 70cm (R-R) and 30cm (P-P) spacing, in randomized block design (RBD) with three replications. Three round spraying of three doses of pyridalyl-15% + fenpropathrin- 20% EC (75+100, 90+120 and 105+140 g a.i./ ha) along with single dose of their individual counterparts; pyridalyl 10% EC (100 g a.i./ ha) and fenpropathrin 30% EC (100 g a.i./ ha) and a combined product chlorpyrifos 50% + cypermethrin 5%EC (500 + 50 g a.i./ ha) and a commonly recommended insecticide (as standard check) viz., indoxacarb 14.5 SC (60 g a.i./ ha) The first round was given at 10% flowering followed by full blooming and bearing stage at 25 days interval. Results revealed that pyridalyl 15% + fenpropathrin 20% EC @ 105+140 g a.i. / ha and 90+120 g a.i./ ha were quite effective and were at par with each other in controlling red gram pod borer complex (*Helicoverpa armigera* Hub., *Exelatis atomosa* Wals. and *Melanagromyza obtusa* Mall.) and recorded higher grain yield (1.96 and 1.85 t/ha, respectively) than rest of the treatments.

Sreekanth *et al.*, (2015) conducted experiment on evaluation of certain insecticides against gram pod borer, *Helicoverpa armigera* (Hubner) infesting pigeonpea (*Cajanus cajan* L.) they reported that the pod damage due to pod borer, *H. armigera* was lowest (5.9%) in plots treated with acetamiprid and dimethoate, followed by fipronil (6.6%) and thiamethoxam (7.2%) with 42.2, 42.2, 35.3 and 29.4 per cent reduction over control, respectively. The untreated plot has recorded maximum pod damage of 10.2%.

Randhawa and Saini (2015) conducted experiment on efficacy of different insecticides against pod borer, (*Maruca vitrata* Geyer) in pigeonpea and it was revealed that the efficacy of different insecticides viz. spinosad 48SC, cypermethrin 25EC, profenophos 50EC and indoxacarb 15EC @ 150, 250, 1250 and 500 ml/ha, respectively against pod borer, *Maruca vitrata* (Geyer) in pigeonpea. significantly decreased the larval population of pod borer, flower incidence, pod damage and increased the grain yield as compared to untreated control. But spinosad 48SC @ 150ml/ha was found to be most effective against test insect and it was closely followed by indoxacarb 15EC and cypermethrin 25EC.

Kumar and Sarada (2015) conducted experiment on field efficacy and economics of some new insecticide molecules against lepidopteran caterpillars in chickpea and it was revealed that the pooled mean of two years showed that the number of *S. exigua* and *H. armigera* larvae per 10 plants were lowest in plots treated with chlorantraniliprole 20% SC (0.33 and 0.50), spinosad 45% SC (0.34 and 0.67) and flubendiamide 20% WG (0.50 and 0.84) as against untreated control plot (16.67 and 8.17 larvae/10 plants) with 98.0, 97.9 and 97.0 per cent reduction of *S. exigua* population and 93.9, 91.8 and 89.7 per cent reduction of *H. armigera* population, respectively. Pod damage due to pod borer, *H. armigera* was lowest in plots treated with spinosad 45% SC (1.53%), flubendiamide 20% WG (2.46%), chlorantraniliprole 20% SC (2.60%) and emamectin benzoate 5% SG (2.85%) with 88.8, 81.9, 80.9 and 79.1 per cent reduction over control, respectively. Highest seed yield was recorded in spinosad 45% SC treated plots (1244.4 kg/ha) with 121.8 per cent increase over control, followed by chlorantraniliprole 20% SC (1180.5 kg/ha), flubendiamide 20% WG (1157.4 kg/ha) and emamectin benzoate 5% SG (1078.7 kg/ha) with 110.4, 106.3 and 92.2 per cent increase over control, respectively as against the minimum yield of 561.1 kg/ha in the untreated control. The cost effectiveness of flubendiamide 20% WG was high with cost-benefit ratio of 1 : 4.08 followed by emamectin benzoate 5% SG (1:3.75), chlorantraniliprole 20% SC and spinosad 45% SC (1:3.57).

2.1: To study the bio-safety of different insecticides against natural enemies.

Acharya *et al.*, (2002) studied on the toxicity of newer molecules of insecticides, acetamiprid (20 g a.i. ha.-1), thiamethoxam (25 g a.i. ha.-1), NACLFMOA (20 g a.i. ha.-1), abamectin (20 g a.i. ha.-1), and were found to be relatively safer to the predatory ladybird beetles.

AL-Kherb (2011) reported that neonicotinoids groups of thiamethoxam 20 WG showed slightly higher toxic effect where it reduced the population of *Chrysoperla carnea*, *Coccinella undecempunctata*, *Orius* sp and *Paederus alferii* by an average of 24.9, 30.2, 38.4 and 32.3 per cent, respectively on tomato crop. Similarly, acetamiprid 20 SP and imidacloprid 17.8 SL also reduced the *C. carnea*, *C. undecempunctata*, *Orius* sp and *P. alferii* population by the average of 20.2, 23.5, 32.3 and 28.4 per cent and they were 22.4, 24.2, 36.1 and 29.81 per cent, respectively. .

Ameta *et al.*, (2010b) evaluated the efficacy of flubendiamide 480 SC@ 37.5, 50, 75 and 100 ml/ha against *Helicoverpa armigera* (Hubner) in chickpea. The most effective treatment was found to be flubendiamide 480 SC@ 100 ml/ha in reducing larval population of pod borer, recording lowest pod damage and increasing seed yield followed by flubendiamide 480 SC@ 75 ml/ha. All the doses of flubendiamide 480SC reported safe to lady bird beetles and *Chrysoperla*.

Ameta *et al.*, (2011b) evaluated relative efficacy of flubendiamide 480 SC at 50, 75 and 100 ml/ha along with indoxacarb 14.5 SC at 500 ml a.i./ha and spinosad 45 SC at 187.5 ml a.i./ha against pigeonpea pod borer viz. *Helicoverpa armigera* (Hubner) and *Maruca testulalis* (L) and found that flubendiamide 480 SCat100 ml/ha caused significantly high reduction in larvae, and recorded minimum flower and pod damage with significantly high seed yield. Insecticidal treatments did not had adverse effect on natural enemies population in pigeonpea.

Dhawan *et al.*, (2009) reported that chlorantraniliprole 20 SC @ 30 g ai/ha was the most effective treatment for the control of bollworm complex on cotton as it did not cause any resurgence in sucking pests and was also safer to natural enemies.

Seal *et al.*, (2007) reported that predatory spider population was considerably lowered immediately following application of insecticides such as metaflumiazone, indoxacarb, novaluron, spinetoram and spinosad but the populations treated with indoxacarb and spinosad had fully recovered by the seven days after treatment.

Singh and Verma (2006) studied that the novaluron was field tested for its bio efficacy against chickpea pod borer, *Helicoverpa armigera* (Hubner) at Agricultural Research Station, Sriganaganagar during 2003-04 and 2004-05 crop seasons in comparison with newer molecules viz. Emamectin benzoate, Indoxacarb and Spinosad. Novaluron, Emamectin benzoate and Spinosad treatments, respectively. Besides, no adverse effects on crop as well as predators and parasites have been observed.

Thilagam *et al.*, (2011) reported that flubendiamide 480 SC @ 36 and 48 g a.i/ha to be least toxic to spiders, coccinellids and *Chrysoperla* population on cotton. However, these populations were affected initially till seven days of application but the population showed increasing trend thereafter.

2.3: To work out the yield and incremental cost benefit ratio.

Sharma *et al.*, (2011) the survey of Marathwada during 2007–08 revealed that the damage by pod flies ranged from 25.5 to 36%. Hence, studies were carried out to assess and devise pest management module, which can go as a component of widely accepted Integrated Pest Management (IPM). The experimental result over two years indicate emamectin benzoate 5 SG in combination with acetamiprid 20 SP or dimethoate 30 EC gave higher grain yield of 1399 and 1392 kg/ha and lower pod fly grain damage (13.30 and 11.95%).

Gupta and Pathak (2009) efficacy of some indigenous neem products, insecticides and their admixtures were tested at Research Farm of College of Agriculture, Tikamgarh during *kharif* 2003-05. The results indicate that admixture treatment, neem seed kernel extract (NSKE) (in cow urine) 3% + dimethoate 0.03% and Neem oil 0.5% + dimethoate 0.03% not only reduced the incidence of white fly but also of pod borer. These treatments gave maximum grain yield of 935 and 902 kg/ha, net profit of Rs 3934 and Rs 3320/ha with incremental cost benefit ratio of 11.2 and 10.9, respectively.

Deshmukh *et al.*, (2010) conducted a field experiment to determine the efficacy of different insecticides against *Helicoverpa armigera* (Hubner) infecting chickpea at Junagadh Agricultural University campus, Junagadh during *Rabi* season of 2008-09. The results revealed that flubendiamide 0.007 per cent, indoxacarb 0.0075 per cent, spinosad 0.009 per cent and emamectin benzoate 0.0015 per cent were found most effective in reducing the *H. armigera* population and pod damage of chickpea. The highest yield was also recorded in the treatment of flubendiamide 0.007 per cent (1850 kg/ha) followed by indoxacarb 0.0075 per cent (1805 kg/ha), spinosad 0.009 per cent (1760 kg/ha) and emamectin benzoate 0.0015 per cent (1665 kg/ha). The highest cost benefit ratio was obtained in the treatment of indoxacarb 0.0075 per cent (1:7.08), followed by flubendiamide 0.007 per cent (1:6.10) and spinosad 0.009 per cent (1:5.24). Thus, considering the cost benefit ratio, any one of these insecticides spray at 50 per cent flowering and second at 15 days after first spray can be suggested for the effective control of gram pod borer on chickpea.

Jagadeesh Babu and Mallicarjun (2012) the results on chemical control of gram pod borer, *Helicoverpa armigera* Hubner infesting pigeonpea indicated that among the different insecticides tested, indoxacarb 0.0075 per cent gave the highest per cent mortality of the pest followed by spinosad 0.009 per-cent, profenophos + cypermethrin 0.044 percent and endosulfan 0.07 per-cent. endosulfan 0.07 percent 0.0075 per-cent recorded significantly highest grain yield (1486 kg/ha). While, highest cost benefit ratio of 1: 18.94 was also obtained from the treatment of endosulfan 0.07 percent.

Priyadarshini *et al.*, (2013) conducted field trial to evaluate comparative efficacy of six insecticides against pod borer complex viz. gram pod borer (*Helicoverpa armigera* Hubner), pod fly (*Melanagromyza obtusa* Malloch), flower webber cum borer (*Maruca vitrata* Geyer) and plume moth (*Exelastis atomosa* Walsingham). Among all the chemicals, used flubendiamide 480 SC at 60 g a.i. ha⁻¹ was found to be the most effective with a maximum reduction in lepidopteran pod borers with pod damage, grain damage and weight loss of 5.3, 3.3 and 2.9 per cent, respectively followed by lambda-cyhalothrin 5 EC at 25 g a.i. ha⁻¹ (8.0, 3.4 and 2.9 %) and indoxacarb 18.5 EC at 18.8 g a.i. ha⁻¹ (10.3, 6.4 and 5.6 %), respectively. The highest net profit was obtained from the treatment flubendiamide 480 SC at 60 g a.i. ha⁻¹ (Rs. 12,638) followed by lambda-cyhalothrin 5 EC at 25 g a.i. ha⁻¹ (Rs. 7092), indoxacarb 18.5 EC at 18.8 g a.i. ha⁻¹ (Rs. 6462.4), while lambda-cyhalothrin 5 EC at 25 g a.i. ha⁻¹ (1:7.5) recorded highest incremental cost benefit ratio followed by lambda-cyhalothrin 5 EC at 25 g a.i. ha⁻¹ (1:4.7) and quinalphos 25 EC at 250 g a.i. ha⁻¹ (1:4.4).

Sreekanth *et al.*, (2013) conducted experiment on bio-efficacy and economics of certain new insecticides against gram pod borer, *Helicoverpa armigera* (Hubner) infesting pigeonpea (*Cajanus cajan* L.) and it was revealed that highest grain yield was recorded in chlorantraniliprole treated plots (686.1 kg/ha) with 127.5 per cent increase over control, followed by flubendiamide (595.8 kg/ha) and spinosad (589.0 kg/ha) with 97.6 and 95.3 per cent increase over control, respectively as against the minimum yield of 301.6 kg/ha in the untreated check. The cost effectiveness of chlorantraniliprole and flubendiamide was also high and very favorable with incremental cost-benefit ratios of 1: 4.64 and 1: 4.50 respectively, followed by indoxacarb (1: 3.67), emamectin benzoate (1: 3.13) and spinosad (1: 2.97).

Wadaskar *et al.*, (2013) evaluated the efficacy of newer insecticides viz., rynaxypyr, spinosad, emamectin benzoate, flubendiamide, indoxacarb along with endosulfan (as standard check) for the management of pigeonpea pod borer complex. Field experiment were conducted at two locations, Pulses Research Unit, Akola (*kharif* 2009-10 and 2010-11) and at Central Demonstration Farm, Wani Rambhapur, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra (*kharif* 2010-11). Mean reduction of *H. armigera* larval population, 7 and 14 days after the treatments, revealed superiority of flubendiamide 20 WDG @ 0.5 g/l, which resulted in reduction to the extent of 96.1 and 95.4 per cent, over control, respectively. Other treatments with economic feasibility were indoxacarb 14.5 SC @0.55 ml/l (ICBR 1:5.1), emamectin benzoate 5 SG @0.3 g/l (1:5.0) and spinosad 45 SC @ 0.3 ml/l (1:4.6) and may also be recommended as potent alternatives in management of pod borer complex of pigeonpea. Rynaxypyr 20 SC @ 0.25 ml/l, though highly efficacious against pest complex could not find a place in set of cost effective treatments.

Singh (2014) reported that pod fly *Melanagromyza obtusa* is a key biotic constraint for productivity in subsistence crop protection pattern. The experiment consisted 6 treatments (trizophos 500 g ai. ha¹, emamectine benzoate 11 g ai. ha¹, emamectine benzoate 11 g ai. ha¹+Acetamiprid 30 g ai.ha¹, flubendiamide 47 g ai. ha¹, chlorantraniliprole 40 g ai. ha¹ and spinosad 75 g ai. ha¹) compare with control. The lowest pod damage (9.7% and 9.3%), lowest grain damage (5.3% and 5%) and highest grain yield (1202 kg ha¹ and 1209 kg ha¹) were obtained from chlorantraniliprole followed by emamectine benzoate + acetamiprid, spinosad, emamectine benzoate, flubendiamide, trizophos and all the treatments were significantly superior over control. The highest B: C ratio reward (1:4.24) was obtained from chlorantraniliprole. The results indicated that chlorantraniliprole was more effectual against pod damage, grain damage, yield and B: C ratio. The safer chemical control methods reduce the pod damage, grain damage and higher yield with high benefit : cost ratio.

Sreekanth *et al.*, (2014) conducted experiment on efficacy of novel insecticides to control Pod fly *Melanagromyza obtuse* affecting pigeonpea (*Cajanus cajan* L.) they reported that the highest grain yield was recorded in chlorantraniliprole treated plots (686.1 kg/ha) with 127.5 per cent increase over control, followed by flubendiamide (595.8 kg/ha), spinosad (589.0 kg/ha) and emamectin benzoate 5% SG (540.0 kg/ha) with 97.6, 95.3 and 79.1 per cent increase

over control (301.6 kg/ha), respectively. The cost effectiveness of chlorantraniliprole and flubendiamide was also high and very favorable with incremental cost-benefit ratios of 1 : 4.64 and 1 : 4.50, respectively, followed by indoxacarb (1 : 3.67), emamectin benzoate (1 : 3.13) and spinosad (1 : 2.97). Khorasiya *et al.*, (2014) conducted experiment on field efficacy of *Helicoverpa armigera* (Hübner) hardwick on pigeonpea they reported that the highest yield was also recorded in the treatment indoxacarb 0.007 per cent (1658 kg/ ha) followed by spinosad 0.005 per cent (1582 kg/ha) and emamectine benzoate 0.005 per cent (1494 kg/ha). The treatment of indoxacarb 0.007 per cent was found most economical as it gave the highest cost benefit ratio (1 :7.546) followed by endosulfan 0.07 per cent (1 : 6.766), cypermethrin 0.006 per cent (1 : 5.492), novaluron 0.01 per cent (1 : 5.376). Considering the overall efficacy, yield and economics of different insecticides. Two sprays of indoxacarb 0.007 per cent, endosulfan 0.07 per cent, cypermethrin 0.006 per cent, novaluron 0.01 per cent can be recommend for effective and economical control of gram pod borer infesting pigeonpea.

Sreekanth *et al.*, (2015) conducted experiment on Efficacy and economics of certain new generation novel insecticides against legume pod borer, *Maruca vitrata* (Geyer) on pigeonpea (*Cajanus cajan* L.) they reported that the highest grain yield was recorded in chlorantraniliprole treated plots (686.1 kg/ha) with 127.5 per cent increase over control, followed by flubendiamide (595.8 kg/ha) and spinosad (589.0 kg/ha) with 97.6 and 95.3 per cent increase over control (301.6 kg/ha), respectively. The cost effectiveness of chlorantraniliprole and flubendiamide was also high and very favorable with incremental cost benefit ratios of 1 : 4.64 and 1 : 4.50 respectively, followed by indoxacarb (1 : 3.67), emamectin benzoate (1 : 3.13) and spinosad (1 : 2.97).

Sreekanth *et al.*, (2015) conducted experiment on evaluation of certain insecticides against gram pod borer, *Helicoverpa armigera* (Hubner) infesting pigeonpea (*Cajanus cajan* L.) they reported that the Highest grain yield was recorded in fipronil treated plots (4.5 q/ha), followed by thiacloprid (4.2 q/ha) and dimethoate (4.0 q/ha) with 50.0, 40.0 and 33.3 per cent increase in yield over control respectively as against the minimum yield of 3.0 q/ha in the untreated check. However, the ICBR was highest in thiamethoxam (1 : 7.8) and dimethoate (1 : 6.2), followed by acetamiprid (1 : 4.1) and thiacloprid (1 :3.4).

CHAPTER - III

MATERIAL AND METHODS

The material used and methods adopted to study the evaluation of sequential application of insecticides against pod borer complex of pigeonpea are presented below.

3.1. Experimental Site and location:

The present investigation was conducted at Research Farm, Department of Agricultural Entomology, Agricultural Research Station, Badnapur, during *kharif* season of 2015-2016. The site selected was uniform with medium black cotton soil having fairly good drainage. Badnapur comes under Central Maharashtra Plateau Zone. Geographically the Agricultural Research Station, is situated at 19.50° latitude and 47.53° longitudes with an altitude of 520 meters.

3.2. Soil Type:

The soil of this farm can be classified in two soil series. Antisol with soil shallow to moderate shallow in depth. Whereas, Vertisol which is major soil consisting about 65% of the farm. These soils are moderately deep to very deep. The soil of this station is also classified on the basis of depth. About 50% soils are low in “N”, medium in available P₂O₅ and K₂O. In general, soils are normal in respect of pH and electrical conductivity (EC).

3.3. Weather Conditions:

Climatically, there are three seasons, *Kharif* season starts from middle of June to middle of September, *Rabi* from October to January and *Summer* from February to May. The average rainfall of the station is 650 mm. This station comes under Central Plateau Zone. The average minimum and maximum temperature during the last five years were 15.25° C and 43.85 °C.

3.4. Experimental Detail:

The seed of pigeonpea variety BSMR-736 were sown during *kharif* 2015-16 to evaluate the sequential application of insecticides against pod borer complex of pigeonpea having plot size 7.20 m x 4.20 m. The dibbling was done at 90 cm x 30 cm spacing on 1st July, 2016.

3.4.1 Design of experiment : Randomized Block Design

- 3.4.2 Number of Replications : Three (3)
- 3.4.3 Number of treatments : Eight (8)
- 3.4.4 Variety : BSMR 736
- 3.4.5 Season : *Kharif* 2016
- 3.4.6 Spacing : 90 cm x30 cm
- 3.4.7 Plot gross : 7.20 m x 4.20 m (8 rows for 4 m length)
- 3.4.8 Date of sowing : 1st July 2016
- 3.4.9 Fertilizer dose : 25:50:00 NPK kg/ha

3.4.10 Treatment details:

Sr. No.	Name of Insecticide	Common Name of Insecticide	Chemical Name	Chemical Formula	Name of Company
1	Acephate 75SP	Asataf	Acephate	C ₄ H ₁₀ NO ₃ PS	Tata
2	Acetamiprid 20SP	Dhanpreet	Acetamiprid	C ₁₀ H ₁₁ CIN ₄	Dhanuka
3	Chlorantraniliprole 18.5%SC	Koragen	Chlorantraniliprole	C ₁₈ H ₁₄ BrCL ₂ NO ₂	DuPont
4	Indoxacarb 15.8 EC	Avaunt	Indoxacarb	C ₂₂ H ₁₇ ClF ₃ N ₃ O	DuPont
5	Flubendiamide 20WG	Takumi	Flubendiamide	C ₂₃ H ₂₂ F ₇ IN ₂ O ₄ S	Tata
6	Dimethoate 30 EC	Rogorus	Dimethoate	C ₅ H ₁₂ NO ₃ PS ₂	Cheminova
7	Untreated control (water spray)				

3.4.11 Crop condition and package of practices

After sowing, intercultural operations as well as fertilizer applications were done as per university recommendations. Due care was taken to maintain proper growth of the crop. Three sequential applications of insecticides spray were applied against pod borer complex of pigeonpea. First spray given at 50 per cent flowering, second spray at pod development and third at pod maturity stage of the crop with hand operated knapsack sprayer as a spray volume of 500 L per ha.

3.5 To evaluate the sequential application of insecticides against pod borer complex of pigeon pea

3.5.1. Methods for recording observations:

So as to evaluate the performance of different sequential application of insecticides for the treatments, number of larval population of gram pod borer, tur plume moth and spotted pod borer webbing were counted and recorded from the randomly five tagged selected plants. Larval population pre-treatment observations were recorded 24 hours before application of treatments and observation recorded on 3rd, 7th and 14th days after spraying. From each observation plant Fifty green pods were randomly collected from each treatment and carefully examined in laboratory to determine the damage caused by pigeonpea pod fly maggot before spraying and 3rd, 7th and 14th days after second and third sequential application of insecticides.

At the time of harvest, 200 pods were collected randomly from each treatment and numbers of healthy and damaged pods were counted to calculate the pod damage and grain damage percentage for gram pod borer and pod fly.

The percent pod damage was calculated by using following formula:

$$\text{Per cent pod damage} = \frac{\text{Number of infested pods}}{\text{Total number of pods}} \times 100$$

Yield of pigeonpea from the net plot was recorded and weighted with the help of electronic weighing balance and converted in to kg/ ha. The data, thus obtained were subjected to statistical analysis for drawing meaningful conclusion.

***Helicoverpa armigera* (Hubner)**

For recording observations on population dynamics of pod borer each plot was divided into five quadrates and from each quadrates, five plants was selected randomly and tagged. The whole experiment replicated thrice. Larval population of *H. armigera* was also recorded from tagged plants in each quadrates pre-treatment observations were recorded 24 hours before application of treatments and 3rd, 7th and

14th days after spraying. For this, each tagged plant was critically examined and larval stages of the pest was counted right from first spraying at 50% flowering to third spraying at pod maturity stage of the pigeonpea crop.

***Melanagromyza obtusa* (Malloch)**

The incidence of pod fly in pigeonpea was recorded on the basis of per cent pod damage. For this, 50 green pods were collected periodically from pod formation stage to till harvesting of the crop and pre-treatment observations were recorded 24 hours before application of treatments and 3rd, 7th and 14th days after spraying. Damaged pods were sorted out by detecting the presence of maggot or pupa, tunneled grains inside the pod and small pin hole window.

***Exelastis atomosa* (Walsingham)**

Five plants were randomly selected from each net plot and three twigs per plant i.e. one each from top, middle and bottom were selected at the time of each observation. The total numbers of *E. atomosa* larvae were recorded on these twigs. Pre-treatment observations were recorded 24 hours before application of treatments and the post-treatment observations were noted on 3rd, 7th and 14th days after every treatment from these, per cent population of *E. atomosa* was calculated separately.

***Maruca vitrata* (Fabricius)**

During present study, the population of *M. vitrata* was observed under field condition to that number of webbings by *M. vitrata* pre-treatment observations were recorded 24 hours before application of treatments and the post-treatment observations were noted on 3rd, 7th and 14th days after every treatment from flowering stage to till harvest of crop.

3.6 To study the bio-safety of different insecticides against natural enemies.

Five plants were randomly selected from each net plot and total numbers of natural enemies i.e. lady bird beetle and spider population were recorded on plant. The pre-treatment observations were recorded 24 hours before application of treatments and post-treatment observations were noted on 3rd, 7th and 14th days after every treatment from these, per cent population of natural enemies was calculated separately.

3.7 Incremental Cost : Benefit Ratio

Benefit cost ratio (BCR) was also assessed by dividing the net monetary return (B) by the total additional cost due to treatments as worked out (C). The values were duly transformed in to the corresponding angular value and subjected to analysis of

variance. Critical difference (CD) was applied for comparing treatment means (Gomez and Gomez, 1984).

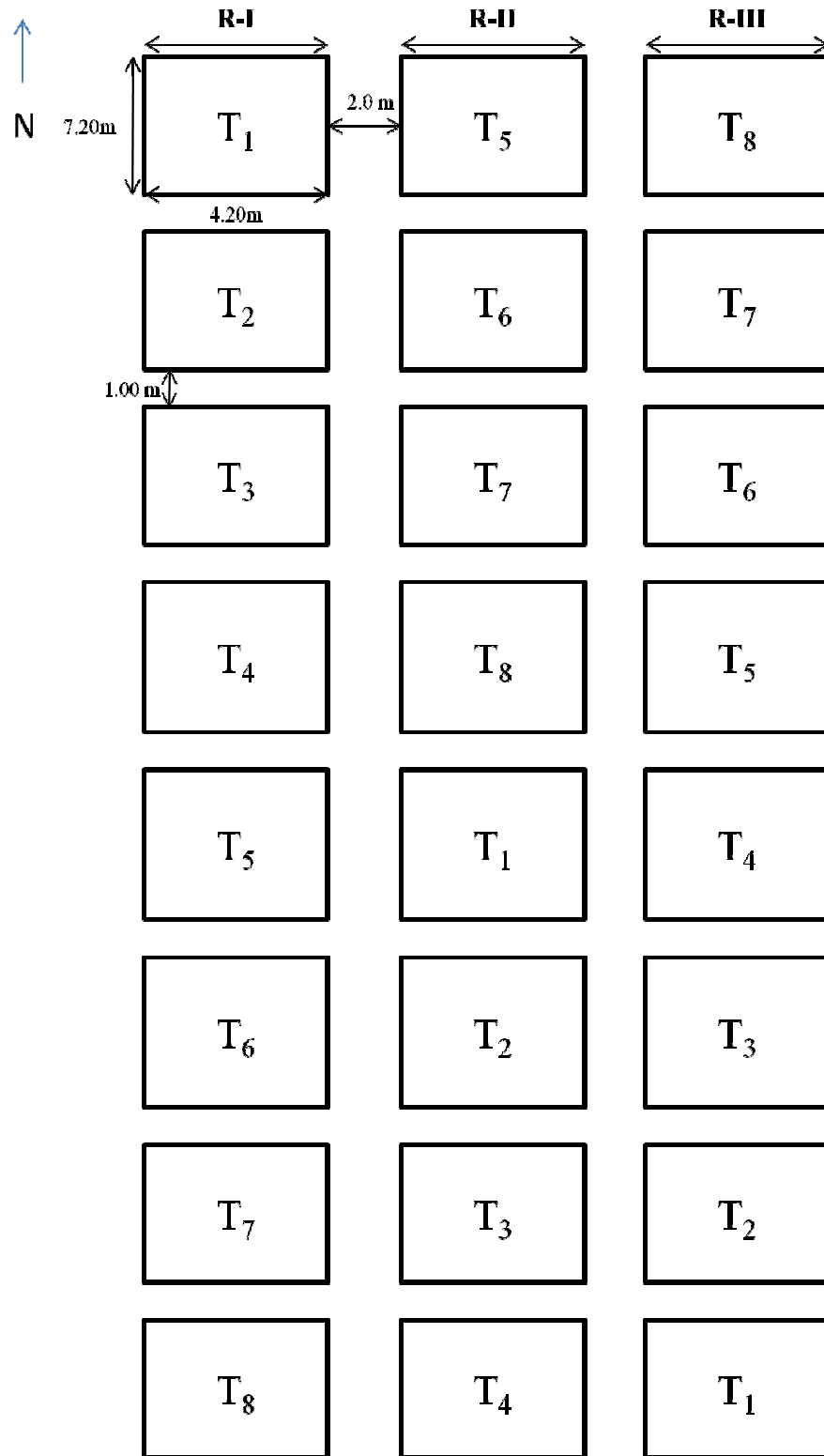


Fig. 1. Layout of Bioefficacy experiment.



PLATE I: A view of experimental site

CHAPTER - IV

RESULTS AND DISCUSSION

Pigeonpea severely attacked by different lepidopterous insect-pests, viz., *Helicoverpa armigera*, *Melanagromyza obtusa*, *Exelastis atomosa* and *Maruca vitrata*. In order to plan the pest control strategies, it was necessary to study the bioefficacy of newer insecticides against pod borer complex of pigeonpea. The literature pertaining to predetermined aspects such as bioefficacy of newer insecticides against pigeonpea pod borer complex infesting pulse crops with major emphasis to pigeonpea presented under following headings and sub headings.

4.1: To evaluate the sequential application of insecticides against pod borer complex of pigeon pea.

4.2: To study the bio-safety of different insecticides against natural enemies.

4.3: To work out the yield and incremental cost benefit ratio.

4.1: To evaluate the sequential application of insecticides against pod borer complex of pigeon pea.

4.1.1- Effect of different insecticides on population of *Helicoverpa armigera*.

4.1.1.1 First spray

Pre-count one day before first spray

The data on *Helicoverpa armigera* population on one day before first spray presented in Table 2 and depicted in Fig. 2. The population ranged between 0.46 to 0.86 larvae / plant. The results were statistically non significant indicating uniform distribution of *Helicoverpa armigera* population.

Three day after first spray

The data presented in Table 2 and graphically represented in Fig. 2. Indicated that there were significant differences among the treatments on three days after first spray. All the treatments recorded significantly lower population of *Helicoverpa armigera* than untreated control. The larval population of *Helicoverpa armigera* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha > flubendiamide 20WG@73 g.a.i/ha > dimethoate 30 EC@600 g.a.i/ha recorded lowest (0.43 larvae / plant) and was at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha > indoxacarb 15.8 EC@73 g.a.i/ha > acetamiprid 20 SP@20 g.a.i/ha (0.50 larvae / plant) followed by T4

chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.63 larvae / plant) and T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.83 larvae / plant). The highest population of *Helicoverpa armigera* (1.10 larvae/plant) was observed in untreated control.

Seven days after first spray

The data are presented in Table 2 and graphically represented in Fig.2. There were significant differences among the treatments on seven days after first spray. All the treatments recorded significantly lower population of *Helicoverpa armigera* larvae over untreated control. The larval population of *Helicoverpa armigera* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha>flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (0.43 larvae / plant) was significantly recorded lowest population and which was at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha>acetamiprid 20 SP@20 g.a.i/ha (0.53 larvae / plant) followed by T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.66 larvae / plant) and T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.83 larvae / plant). The highest larval population of *Helicoverpa armigera* (1.10 larvae / plant) was observed in untreated control.

Fourteen days after first spray

The data are presented in Table 2 and graphically represented in Fig.2. There were significant differences among the treatments on Fourteen days after first spray. All the treatments recorded significantly lower population of *H. armigera* than untreated control. The lowest population of larvae of *H. armigera* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha>flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (0.53 larvae / plant) which was statistically significant and at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha>acetamiprid 20 SP@20 g.a.i/ha (0.60 larvae / plant) followed by T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.73 larvae / plant) T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.83 larvae / plant), T2 Acetamiprid 20SP@20 g.a.i/ha (1.00 larvae / plant), T₁ acephate 75SP@750 g.a.i/ha (1.16 larvae / plant), and T7 dimethoate 30 EC@600 g.a.i/ha (1.16 larvae / plant). The highest larval population of *Helicoverpa armigera* (1.20 larvae / plant) was observed in untreated control.

Where as, first spray of insecticide as chlorantraniliprole 18.5% SC @ 30 g ai/ha recorded the lowest larval population of *Helicoverpa armigera* after 3,7 and 14 days after spray.

Table 2: Efficacy of different insecticides against population of *Helicoverpa armigera* on pigeonpea after First spray.

Tr No.	Treatments	Dosages (g.a.i/ha)	Mean number of <i>Helicoverpa</i> larvae per plant			
			1DBS	3 DAS	7DAS	14 DAS
T ₁	Acephate 75 SP @ 0.15 %	750	0.60 (1.05)	0.93 (1.19)	0.96 (1.21)	1.16 (1.29)
T ₂	Acetamiprid 20 SP @ 0.004 %	20	0.86 (1.16)	0.90 (1.18)	0.93 (1.19)	1.00 (1.22)
T ₃	Chlorantraniliprole 18.5%SC >Acephate 75SP	30 750	0.73 (1.10)	0.83 (1.15)	0.83 (1.15)	0.83 (1.15)
T ₄	Chlorantraniliprole 18.5%SC >Acetamiprid 20SP	30 20	0.46 (0.98)	0.63 (1.06)	0.66 (1.08)	0.73 (1.10)
T ₅	Chlorantraniliprole 18.5%SC >Indoxacarb 15.8 EC >Acetamiprid 20 SP	30 73 20	0.53 (1.01)	0.50 (1.00)	0.53 (1.02)	0.60 (1.05)
T ₆	Chlorantraniliprole 18.5%SC >Flubendiamide 20WG >Dimethoate 30 EC	30 73 600	0.60 (1.05)	0.43 (0.96)	0.43 (0.97)	0.53 (1.02)
T ₇	Dimethoate 30 EC	600	0.80 (1.14)	0.96 (1.21)	1.06 (1.25)	1.16 (1.28)
T ₈	Untreated Control	-	0.53 (1.01)	1.10 (1.26)	1.10 (1.26)	1.20 (1.30)
	SE ±		0.07	0.06	0.06	0.06
	CD at 5%		NS	0.19	0.20	0.20
	CV		11.80	9.94	10.14	10.22

Figures in parentheses are $\sqrt{x + 0.50}$ transformed value

DBS- Day before spray. DAS - Days after spray.

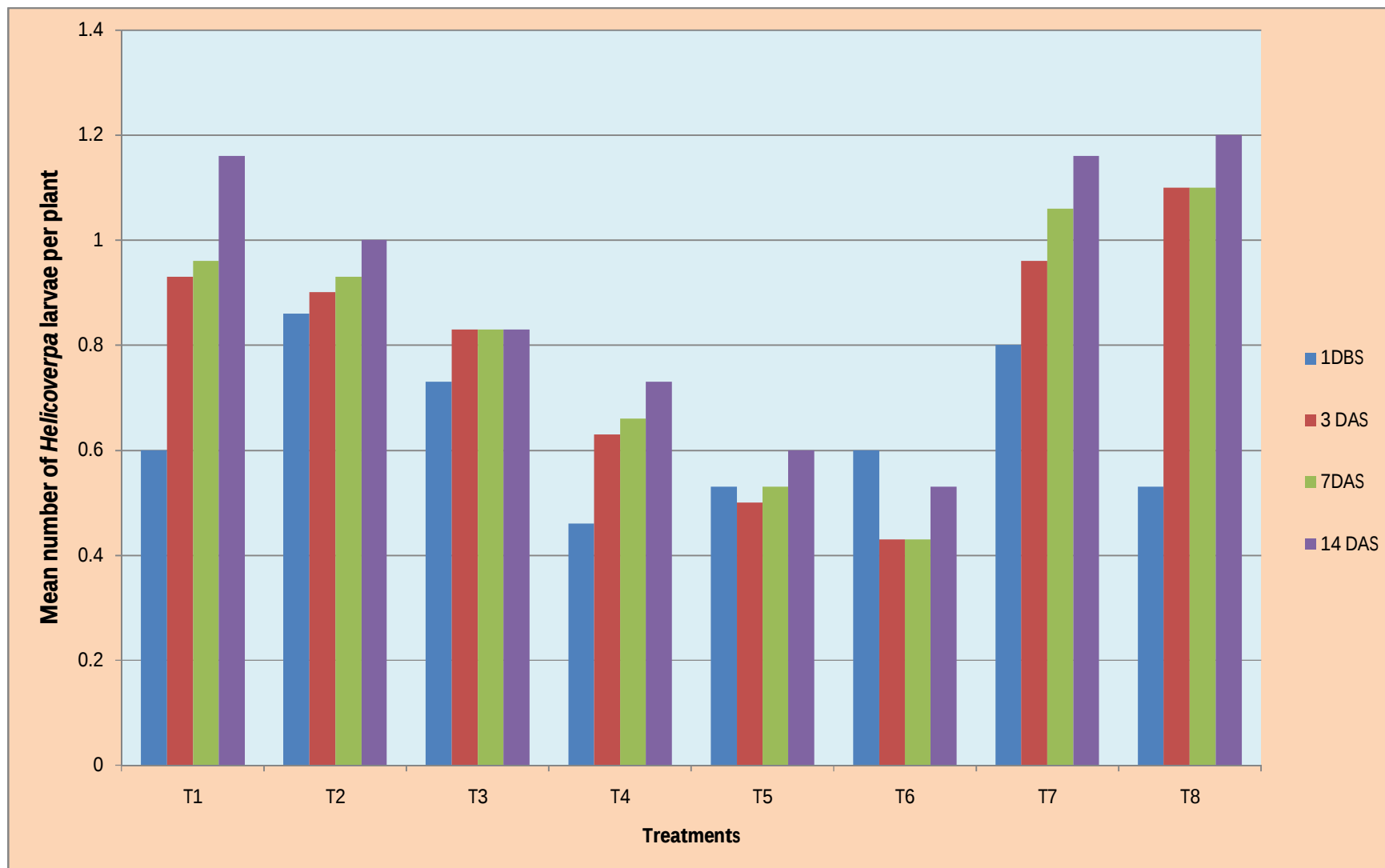


Fig 2 : Efficacy of different insecticides against population of *Helicoverpa armigera* after First spray.

4.1.1.2 Second spray

Pre-count one day before second spray

The data on *Helicoverpa armigera* population one day before second spray which is presented in Table 3 and depicted in Fig. 3. The population of *Helicoverpa armigera* ranged between 0.86 to 1.73 larvae / plant. The results were statistically non significant indicating uniform distribution of *Helicoverpa armigera* population, before second spray of insecticides as per treatments.

Three days after second spray

The data presented in Table 3 and graphically represented in Fig.3. There were significant differences among the treatments after three days of second spray. All the treatments recorded significantly lower population of *Helicoverpa armigera* than untreated control. The larval population of *Helicoverpa armigera* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was lowest (0.43 larvae / plant) which was found significant and at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha>acetamiprid 20 SP@20 g.a.i/ha (0.46 larvae / plant) The next best T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.90 larvae / plant) followed by T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.90 larvae / plant), T2 acetamiprid 20SP@20 g.a.i/ha (0.90 larvae / plant) , T₁ acephate 75SP@750 g.a.i/ha (0.93 larvae / plant), and T7 dimethoate 30 EC@600 g.a.i/ha (1.03 larvae / plant). The highest larval population of *Helicoverpa armigera* (1.80 larvae /plant) was observed in untreated control.

Seven days after second spray

The data are presented in Table 3 and graphically represented in Fig.3. There were significant differences among the treatments on Seven days after second spray. All the treatments recorded significantly lower population of *Helicoverpa armigera* than untreated control. The larval population of *Helicoverpa armigera* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was lowest (0.43 larvae / plant) and was found statistically at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha>acetamiprid 20 SP@20 g.a.i/ha (0.50 larvae / plant) The next best treatment T2 acetamiprid 20SP@20 g.a.i/ha (0.90 larvae / plant) followed by T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.90 larvae / plant), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750

g.a.i/ha (0.93 larvae / plant), T₁ acephate 75SP@750 g.a.i/ha (0.96 larvae / plant), and T7 dimethoate 30 EC@600 g.a.i/ha (1.03 larvae / plant). The highest larval population of *Helicoverpa armigera* (1.66 larvae / plant) was observed in untreated control.

Fourteen days after second spray

The data presented in Table 3 and graphically represented in Fig.3. Indicated that was significant differences among the treatments on Fourteen days after second spray. All the treatments recorded significantly lower larval population of *Helicoverpa armigera* as compared to untreated control. The population of *Helicoverpa armigera* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was recorded lowest (0.50 larvae / plant) which was from statistically significant and which was at par with the T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha>acetamiprid 20 SP@20 g.a.i/ha (0.60 larvae / plant) followed by T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.93 larvae / plant), and T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.96 larvae / plant), T₁ acephate 75SP@750 g.a.i/ha (1.00 larvae / plant), and T7 dimethoate 30 EC@600 g.a.i/ha (1.06 larvae / plant). The highest larval population of *Helicoverpa armigera* (1.53 larvae / plant) was observed in untreated control.

Table 3: Efficacy of different insecticides against population of *Helicoverpa armigera* after second spray.

Tr. No.	Treatments	Dosages (g.a.i/ha)	Mean number of <i>Helicoverpa</i> larvae per plant			
			1DBS	3 DAS	7DAS	14 DAS
T ₁	Acephate 75 SP @ 0.15 %	750	0.93 (1.19)	0.93 (1.20)	0.96 (1.21)	1.00 (1.22)
T ₂	Acetamiprid 20 SP @ 0.004 %	20	0.93 (1.19)	0.90 (1.17)	0.90 (1.17)	1.03 (1.23)
T ₃	Chlorantraniliprole 18.5%SC >Acephate 75SP	30 750	0.86 (1.16)	0.90 (1.17)	0.93 (1.19)	0.96 (1.20)
T ₄	Chlorantraniliprole 18.5%SC >Acetamiprid 20SP	30 20	0.93 (1.19)	0.90 (1.17)	0.90 (1.18)	0.93 (1.18)
T ₅	Chlorantraniliprole 18.5%SC >Indoxacarb 15.8 EC >Acetamiprid 20 SP	30 73 20	0.93 (1.19)	0.46 (0.98)	0.50 (1.00)	0.60 (1.05)
T ₆	Chlorantraniliprole 18.5%SC >Flubendiamide20WG >Dimethoate 30 EC	30 73 600	1.00 (1.22)	0.43 (0.96)	0.43 (0.96)	0.50 (1.00)
T ₇	Dimethoate 30 EC	600	0.93 (1.19)	1.03 (1.23)	1.03 (1.23)	1.06 (1.25)
T ₈	Untreated Control	-	1.73 (1.49)	1.80 (1.52)	1.66 (1.47)	1.53 (1.42)
	SE $\pm$		0.07	0.06	0.06	0.07
	CD at 5%		NS	0.20	0.20	0.21
	CV		10.03	10.17	10.03	10.55

Figures in parentheses are $\sqrt{x + 0.50}$ transformed value

DBS- Day before spray. DAS - Days after spray.

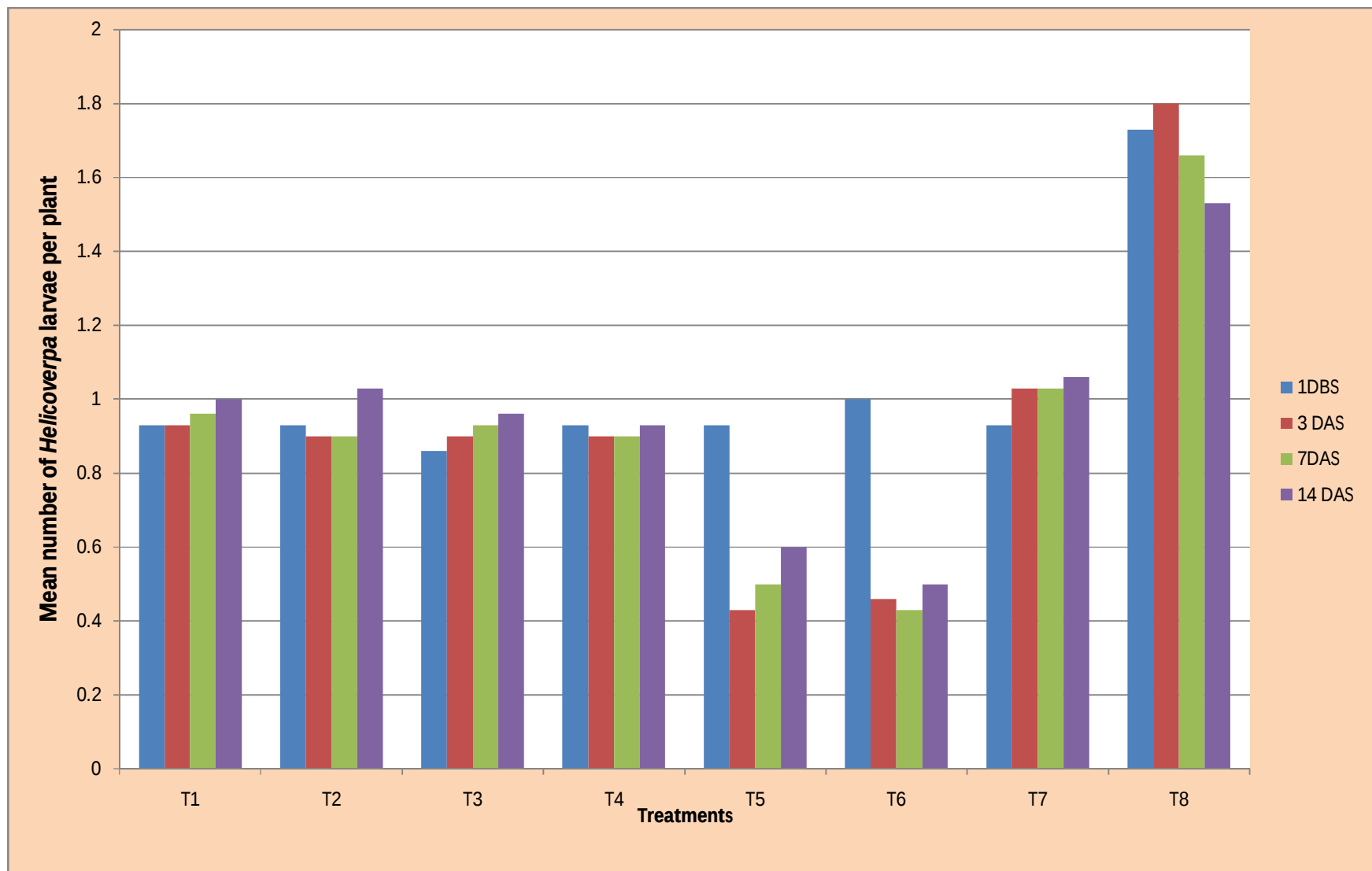


Fig 3: Efficacy of different insecticides against population of *Helicoverpa armigera* after second spray.

4.1.1.3 Third spray

Pre-count one day before third spray

The data on *Helicoverpa armigera* larval population on one day before third spray presented in Table 4 and depicted in Fig. 4. The larval population of *H. armigera* ranged between 0.46 to 1.20 larvae / plant. The results were statistically non significant indicating uniform distribution of *Helicoverpa armigera* population.

Three days after third spray

The data presented in Table 4 and graphically represented in Fig.4. There were significant differences among the treatments three days after third spray. All the treatments recorded significantly lower population of *H. armigera* than untreated control. The lowest larval population of *H. armigera* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was recorded to be (0.30 larvae / plant) and was at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha>acetamiprid 20 SP@20 g.a.i/ha (0.36 larvae / plant). The next best treatment T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.70 larvae / plant) followed by T1 acephate 75SP@750 g.a.i/ha (0.73 larvae / plant), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.80 larvae / plant), T2 acetamiprid 20SP@20 g.a.i/ha (0.76 larvae / plant) and T7 dimethoate 30 EC@600 g.a.i/ha (0.96 larvae / plant). The highest larval population of *H. armigera* (1.30 larvae /plant) was observed in untreated control.

Seven days after third spray

The data are presented in Table 4 and graphically represented in Fig.4. Indicated that were significant differences among the treatments on Seven days after third spray. All the treatments recorded significantly lower population of *H. armigera* than untreated control. The significantly lowest population of *H. armigera* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was recorded lowest (0.36 larvae / plant). which was at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha>acetamiprid 20 SP@20 g.a.i/ha (0.53 larvae / plant). The next better T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.80 larvae / plant), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.83 larvae / plant), T2 acetamiprid 20SP@20 g.a.i/ha (0.83 larvae / plant), T₁ acephate 75SP@750 g.a.i/ha (0.86 larvae / plant), and T7 dimethoate 30 EC@600

g.a.i/ha (1.03 larvae / plant). which was recorded lowest population of *H. armigera* as compared to untreated control. The highest larval population of *H. armigera* (1.60 larvae / plant) was observed in untreated control.

Fourteen days after third spray

The data presented in Table 4 and graphically represented in Fig.4. There were significant differences among the treatments Fourteen days after third spray. All the treatment recorded significantly lower population of *H. armigera* than untreated control. The larval population of *H. armigera* in treatment T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was lowest (0.50 larvae / plant). which was found statistically significant and at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha>acetamiprid 20 SP@20 g.a.i/ha (0.60 larvae / plant). followed by T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.90 larvae / plant), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.90 larvae / plant), T2 Acetamiprid 20SP@20 g.a.i/ha (0.90 larvae / plant) ,T₁ acephate 75SP@750 g.a.i/ha (0.96 larvae / plant) and T7 dimethoate 30 EC@600 g.a.i/ha (0.96 larvae / plant). The highest larval population of *Helicoverpa armigera* (1.66 larvae / plant) was observed in untreated control.

The experimental results revealed that chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was effective in controlling *Helicoverpa armigera* population in all sprays. Similar results were reported by *Patel and Patel et al.*, (2013) reported that the bio-efficacy of newer insecticides against pod borer complex of pigeonpea and it was revealed that among the various insecticides, chlorantraniliprole @ 30 g a.i./ha was the most effective insecticide against gram pod borer and blue butterfly, while profenophos 50 EC @ 250 g a.i./ha was the most effective insecticide against tur plume moth. Chlorantraniliprole 18.5 % SC @ 30 g a.i./ha recorded the lowest pod damage by pod borer and pod fly and also recorded the highest yield of pigeonpea. Similarly by *Sreekanth et al.*, (2013) also conducted experiment on bio-efficacy and economics of certain new insecticides against gram pod borer, *Helicoverpa armigera* (Hubner) infesting pigeonpea (*Cajanus cajan* L.) at Regional Agricultural Research Station, Lam, Guntur, Andhra Pradesh. It was revealed that the number of *Helicoverpa larvae* per plant were lowest in plots treated with chlorantraniliprole 20 SC (0.43), flubendiamide 480 SC (0.59) and spinosad 45 SC (0.85) as against untreated control

plot (4.17) with 89.7, 85.9 and 79.6 per cent larval reduction over control, respectively. Pod damage due to pod borer, *Helicoverpa* was lowest in plots treated with flubendiamide (1.16%), chlorantraniliprole (1.26%) and spinosad (1.92%) with 88.7, 87.7 and 81.2 per cent reduction over control respectively. The untreated plot has recorded maximum pod damage of 10.22%. Similarly Deshmukh *et al.* (2010) determined that flubendiamide 0.007 per cent in pigeonpea was found the most effective in reducing the *H. armigera* population and pod damage and gave the highest yield of 1850 Kg ha⁻¹ and cost benefit ratio of 1:6.10. and Ameta *et al.*, (2010) the experiment on the efficacy of flubendiamide 480 SC at the rate of 37.5, 50, 75 and 100 ml/ha, along with Quinalphos 25 EC @ 1000ml, acephate 75 SP @ 625 ml and endosulfan 35 EC @ 1000 ml/ha against *H. armigera* in chickpea was conducted at R.C.A. Udaipur during rabi 2008-09 and 2009-10. Among all the treatments flubendiamide 480 SC at the rate of 100 ml/ha, was found significantly superior to all treatments and it caused highest reduction in the larval population of pod borer. It was followed by Flubendiamide 480 SC at the rate of 75 ml/ha. flubendiamide 480 SC at 100 ml/ha recorded the significantly highest yield of 17.19 and 18.06 q/ha during rabi 2008-09 and 2009-10, respectively. It was at par and followed by flubendiamide 480 SC at 75 ml/ha which yielded 16.36 and 16.94 q/ha as against 10.41 and 9.93 q/ha in control during Rabi 2008-09 and 2009-10, respectively.

Table 4: Efficacy of different insecticides against population of *Helicoverpa armigera* after third spray.

Tr. No.	Treatments	Dosages (g.a.i/ha)	Mean number of <i>Helicoverpa</i> larvae per plant			
			1DBS	3 DAS	7DAS	14 DAS
T ₁	Acephate 75 SP @ 0.15 %	750	0.80 (1.14)	0.73 (1.11)	0.86 (1.16)	0.96 (1.19)
T ₂	Acetamiprid 20 SP @ 0.004 %	20	0.66 (1.08)	0.76 (1.12)	0.83 (1.15)	0.90 (1.18)
T ₃	Chlorantraniliprole 18.5%SC >Acephate 75SP	30 750	0.66 (1.07)	0.80 (1.13)	0.83 (1.15)	0.90 (1.18)
T ₄	Chlorantraniliprole 18.5%SC >Acetamiprid 20SP	30 20	0.46 (0.98)	0.70 (1.09)	0.80 (1.14)	0.90 (1.18)
T ₅	Chlorantraniliprole 18.5%SC >Indoxacarb 15.8 EC >Acetamiprid 20 SP	30 73 20	0.53 (1.02)	0.36 (0.93)	0.53 (1.01)	0.60 (1.04)
T ₆	Chlorantraniliprole 18.5%SC >Flubendiamide20WG >Dimethoate 30 EC	30 73 600	0.60 (1.05)	0.30 (0.89)	0.36 (0.93)	0.50 (1.00)
T ₇	Dimethoate 30 EC	600	0.66 (1.08)	0.96 (1.21)	1.03 (1.23)	0.96 (1.21)
T ₈	Untreated Control	-	1.20 (1.29)	1.30 (1.34)	1.60 (1.44)	1.66 (1.47)
	SE ±		0.06	0.06	0.06	0.06
	CD at 5%		NS	0.19	0.20	0.20
	CV		10.13	10.27	10.17	10.05

Figures in parentheses are $\sqrt{x + 0.50}$ transformed value DBS- Day before spray. DAS - Days after spray.

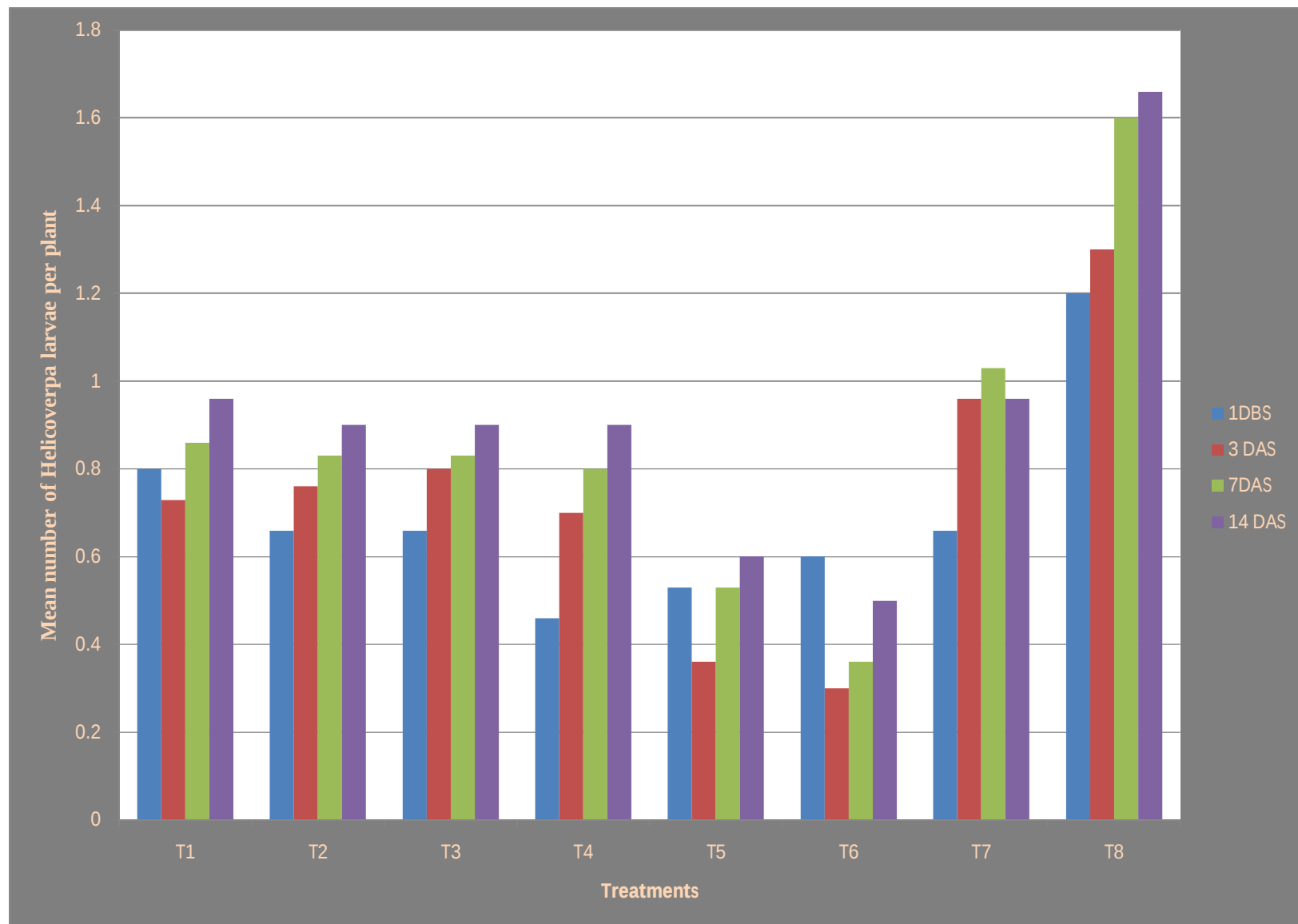


Fig4: Efficacy of different insecticides against population of *Helicoverpa armigera* after third spray.

4.1.2 Effect of different insecticides on population of *Maruca vitrata*.

4.1.2.1 First spray: The population of spotted pod borer, *Maruca vitrata* where not observed during first spray.

4.1.2.2 Second spray

Pre-count one day before first spray

The data on population *M. vitrata* one day before second spray presented in Table 5 and depicted in Fig. 5. The population of *M. vitrata* ranged between (0.50 to 1.03 webblings /plant). The results were statistically non significant indicating uniform distribution of *M. vitrata* population.

Three day after second spray

The data presented in Table 5 and graphically represented in Fig.5. There were significant differences among the treatments three days after second spray. All the treatments recorded significantly lower population of *M. vitrata* than untreated control. The population of *M. vitrata* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was recorded lowest (0.23 webblings / plant). which was found statistically significant and at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha(0.40 webbing / plant). The next best treatment T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha(0.60 webblings /plant) followed by T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.63 webbing / plant), T2 acetamiprid 20SP@20 g.a.i/ha (0.70 webblings /plant), T₁ acephate 75SP@750 g.a.i/ha (0.73 webblings /plant), and dimethoate 30 EC@600 g.a.i/ha (0.76 webblings /plant). The highest population of *Maruca vitrata* (0.86 / plant) was observed in untreated control.

Seven day after second spray

The data presented in Table 5 and graphically represented in Fig.5. There were significant differences among the treatments on seven days after second spray. All the treatments recorded significantly lower population of *Maruca vitrata* than untreated control. The population of *Maruca vitrata* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was recorded lowest (0.30 webblings / plant). which was found statistically significant and at par with T5

chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha(0.46 webbing / plant). The next best treatment T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.70 webbings /plant) followed by T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.76 webbing / plant), T2 acetamiprid 20SP@20 g.a.i/ha (0.76 webbings /plant) T₁ acephate 75SP@750 g.a.i/ha (0.83 webbings /plant) and dimethoate 30 EC@600 g.a.i/ha (0.86 webbings /plant). The highest population of *Maruca vitrata* (1.03 webbings /plant) was observed in untreated control.

Fourteen day after second spray

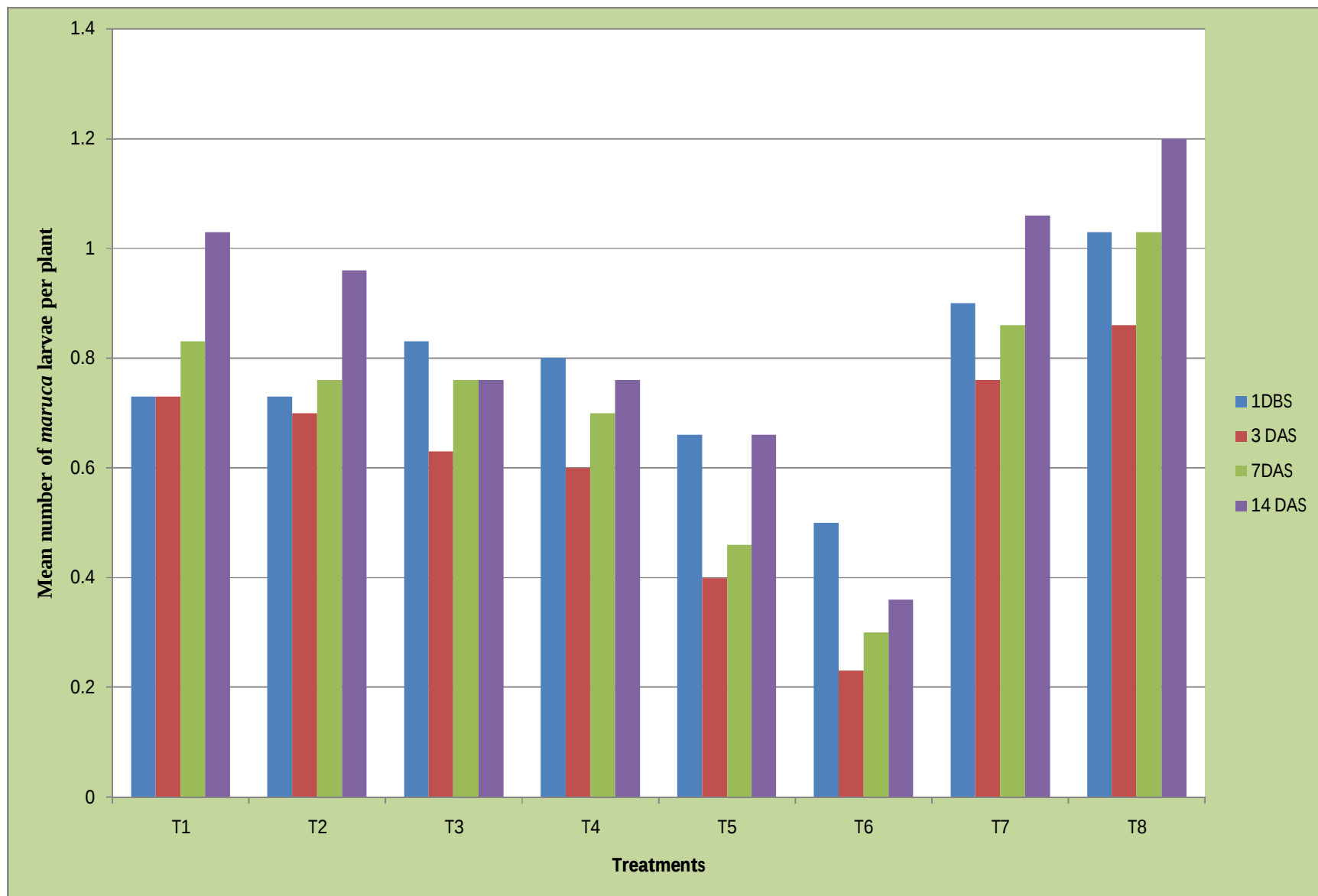
The data are presented in Table 5 and graphically represented in Fig.5. Indicated that were significant differences among the treatments on fourteen days after second spray. All the treatments recorded significantly lower population of *M. vitrata* than untreated control. The population of *M. vitrata* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was recorded lowest (0.36 webbings / plant). which was found statistically significant and at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha(0.66 webbing / plant). Followed by T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.76 webbings /plant), and T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.76 webbing / plant). T2 Acetamiprid 20SP@20 g.a.i/ha (0.96 larvae / plant) , T₁ acephate 75SP@750 g.a.i/ha (1.03 larvae / plant) and T7 dimethoate 30 EC@600 g.a.i/ha (1.06 larvae / plant). The highest population of *Maruca vitrata* (1.20 webbings /plant) was observed in untreated control.

Table 5: Efficacy of different insecticides against population of *Maruca vitrata* after (second spray)

Tr. No.	Treatments	Dosages (g.a.i/ha)	Mean number of webbing larvae per plant			
			1DBS	3 DAS	7DAS	14 DAS
T ₁	Acephate 75 SP @ 0.15 %	750	0.73 (1.09)	0.73 (1.10)	0.83 (1.15)	1.03 (1.23)
T ₂	Acetamiprid 20 SP @ 0.004 %	20	0.73 (1.10)	0.70 (1.10)	0.76 (1.13)	0.96 (1.21)
T ₃	Chlorantraniliprole 18.5%SC >Acephate 75SP	30 750	0.83 (1.15)	0.63 (1.06)	0.76 (1.12)	0.76 (1.13)
T ₄	Chlorantraniliprole 18.5%SC >Acetamiprid 20SP	30 20	0.80 (1.12)	0.60 (1.05)	0.70 (1.10)	0.76 (1.13)
T ₅	Chlorantraniliprole 18.5%SC >Indoxacarb 15.8 EC >Acetamiprid 20 SP	30 73 20	0.66 (1.08)	0.40 (0.95)	0.46 (0.98)	0.66 (1.08)
T ₆	Chlorantraniliprole 18.5%SC >Flubendiamide20WG >Dimethoate 30 EC	30 73 600	0.50 (1.00)	0.23 (0.86)	0.30 (0.89)	0.36 (0.93)
T ₇	Dimethoate 30 EC	600	0.90 (1.16)	0.76 (1.12)	0.86 (1.17)	1.06 (1.25)
T ₈	Untreated Control	-	1.03 (1.23)	0.86 (1.16)	1.03 (1.22)	1.20 (1.28)
	SE $\pm$		0.09	0.06	0.06	0.06
	CD at 5%		NS	0.18	0.19	0.21
	CV		14.83	10.30	10.20	10.49

Figures in parentheses are $\sqrt{x + 0.50}$ transformed value

DBS- Day before spray. DAS - Days after spray.



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Fig 5 : Efficacy of different insecticides against population of *Maruca vitrata* after second spray

4.1.2.3 Third spray

Pre-count one day before third spray

The data on population of *M. vitrata* one day before third spray presented in Table 6 and depicted in Fig. 6. The population of *M. vitrata* ranged between (0.63 to 1.00 webbing / plant). The results were statistically non significant indicating uniform distribution of *M. vitrata* population.

Three day after third spray

The data presented in Table 6 and graphically represented in Fig.6. There was significant differences among the treatments on three days after third spray. All the treatments recorded significantly lower population of *M. vitrata* than untreated control. The population of *M. vitrata* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha > flubendiamide 20WG@73 g.a.i/ha > dimethoate 30 EC@600 g.a.i/ha was recorded lowest (0.30 webbing / plant). which was found statistically significant and at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha > Indoxacarb 15.8 EC@73 g.a.i/ha > acetamiprid 20 SP@20 g.a.i/ha (0.40 webbing / plant) and T7 dimethoate 30 EC@600 g.a.i/ha (0.70 webbing / plant). The next best treatment T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha > acetamiprid 20SP@20 g.a.i/ha (0.70 webbing / plant), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha > acephate 75SP@750 g.a.i/ha (0.70 webbing / plant), T2 acetamiprid 20SP@20 g.a.i/ha (0.70 webbing / plant) and T₁ acephate 75SP@750 g.a.i/ha (0.73 webbing / plant). The highest population of *M. vitrata* (1.03 webbing / plant) was observed in untreated control.

Seven days after third spray

The data presented in Table 6 and graphically represented in Fig.6. There was significant differences among the treatments on seven days after third spray. All the treatments recorded significantly lower population of *M. vitrata* than untreated control. The population of *M. vitrata* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha > flubendiamide 20WG@73 g.a.i/ha > dimethoate 30 EC@600 g.a.i/ha was recorded lowest (0.33 webbing / plant). which was found statistically significant and at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha > Indoxacarb 15.8 EC@73 g.a.i/ha > acetamiprid 20 SP@20 g.a.i/ha (0.50 webbing / plant). The next best treatment T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha > acetamiprid 20SP@20 g.a.i/ha (0.73

webbings /plant), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.73 webbing / plant), T2 acetamiprid 20SP@20 g.a.i/ha (0.76 webbings /plant), T₁ acephate 75SP@750 g.a.i/ha (0.76 webbings /plant), and T7 dimethoate 30 EC@600 g.a.i/ha (0.86 webbings /plant) .The highest population of *M. vitrata* (1.20 webbings /plant) was observed in untreated control.

Fourteen day after third spray

The data presented in Table 6 and graphically represented in Fig.6. There were significant differences among the treatments on fourteen days after third spray. All the treatments recorded significantly lower population of *M. vitrata* than untreated control. The lower population of *M. vitrata* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was recorded lowest (0.43 webbings / plant). which was found statistically significant and at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >Indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.63 webbing / plant). Followed by T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.76 webbings / plant) T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.76 webbing / plant). T2 Acetamiprid 20SP@20 g.a.i/ha (0.90 larvae / plant) , T₁ acephate 75SP@750 g.a.i/ha (0.90 larvae / plant) and T7 dimethoate 30 EC@600 g.a.i/ha (1.00 larvae / plant). The highest population of *Maruca vitrata* (1.33 webbings /plant) was observed in untreated control.

The results obtained from the study noticed that chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was effective in reducing the population of spotted pod borer, (*M. vitrata*) in all sprays , the present findings are accordance with the Sambathkumar et al., (2015) conducted experiment on field evaluation of newer insecticide molecules and botanicals against pod borers of red gram and they reported that the least incidence of *M. vitrata* was recorded in indoxacarb 15.8 EC @ 75 g a.i./ha (3.1 webbings/10 plants) and chlorantraniliprole 18.5 SC 30 g a.i./ha (3.9 webbings/10 plants). The minimum larval population of *H. armigera* was recorded in chlorantraniliprole 18.5 SC @ 30 g a.i./ha (9.5 nos./10 plants) and indoxacarb 15.8 EC @ 73g a.i/ha (10.3 nos./10 plants). Low per cent pod fly grain damage (11.7) was recorded in chlorantraniliprole 18.5 SC @ 30 g a.i./ha with the highest yield of 892.2 kg/ha in

indoxacarb 15.8 EC @ 75g a.i/ha. Similarly reported Yadav *et al.*, (2014) studies were conducted to know the efficacy of some new molecule insecticides (azadirachtin, Bt, endosulfan 35% EC, thiodicarb 75% WP, spinosad 45% SC, lambda cyhalothrin 5% EC, indoxacarb 14.5% SC, profenophos 50% EC and acetamiprid 20% SP) against spotted pod borer, *M. vitrata* on mungbean. The spinosad 45% SC and indoxacarb 14.5% SC were the most effective treatments and significantly superior to other treatments with 80.7 and 79.2 per cent larval reduction over control. The least effective treatments were acetamiprid 20% SP, followed by azadirachtin with 38.8 and 44.9 per cent reduction in larval population over control. The maximum yield was recorded in treatment indoxacarb 14.5% SC (11.8 q/ha) followed spinosad 45% SC (11.1 q/ha) which were at par with each other. While lowest yield was recorded in azadirachtin (9.7 q/ha).and Randhawa and saini *et al.*, (2015) reported experiment on Efficacy of different insecticides against pod borer, (*Maruca vitrata* Geyer) in pigeonpea and it was revealed that The Efficacy of different insecticides viz. Spinosad 48SC, Cypermethrin 25EC, Profenophos 50EC and Indoxacarb 15EC @ 150, 250, 1250 and 500 ml/ha, respectively against pod borer, *Maruca vitrata* (Geyer) in pigeonpea was tested. All tested insecticides significantly decreased the larval population of pod borer, flower incidence, pod damage and increased the grain yield as compared to untreated control. But Spinosad 48SC @ 150ml/ha was found to be most effective against test insect and it was closely followed by Indoxacarb 15EC and Cypermethrin 25EC.

Table 6: Efficacy of different insecticides against population of *Maruca vitrata* after (third spray)

Tr. No.	Treatments	Dosages (g.a.i/ha)	Mean number of webbing larvae per plant			
			1DBS	3 DAS	7DAS	14 DAS
T ₁	Acephate 75 SP @ 0.15 %	750	0.83 (1.15)	0.73 (1.11)	0.76 (1.14)	0.90 (1.18)
T ₂	Acetamiprid 20 SP @ 0.004 %	20	0.76 (1.12)	0.70 (1.10)	0.76 (1.12)	0.90 (1.19)
T ₃	Chlorantraniliprole 18.5%SC >Acephate 75SP	30 750	0.90 (1.17)	0.70 (1.09)	0.73 (1.11)	0.76 (1.13)
T ₄	Chlorantraniliprole 18.5%SC >Acetamiprid 20SP	30 20	0.83 (1.15)	0.70 (1.09)	0.73 (1.11)	0.76 (1.12)
T ₅	Chlorantraniliprole 18.5%SC >Indoxacarb 15.8 EC >Acetamiprid 20 SP	30 73 20	0.63 (1.06)	0.40 (0.95)	0.50 (1.00)	0.63 (1.06)
T ₆	Chlorantraniliprole 18.5%SC >Flubendiamide20WG >Dimethoate 30 EC	30 73 600	0.63 (1.07)	0.30 (0.89)	0.33 (0.91)	0.43 (0.96)
T ₇	Dimethoate 30 EC	600	0.70 (1.08)	0.70 (1.08)	0.86 (1.16)	1.00 (1.22)
T ₈	Untreated Control	-	1.00 (1.22)	1.03 (1.23)	1.20 (1.30)	1.33 (1.34)
	SE $\pm$		0.07	0.06	0.06	0.06
	CD at 5%		NS	0.19	0.19	0.21
	CV		12.08	10.24	10.32	10.50

Figures in parentheses are $\sqrt{x + 0.50}$ transformed value

DBS- Day before spray. DAS - Days after spray.

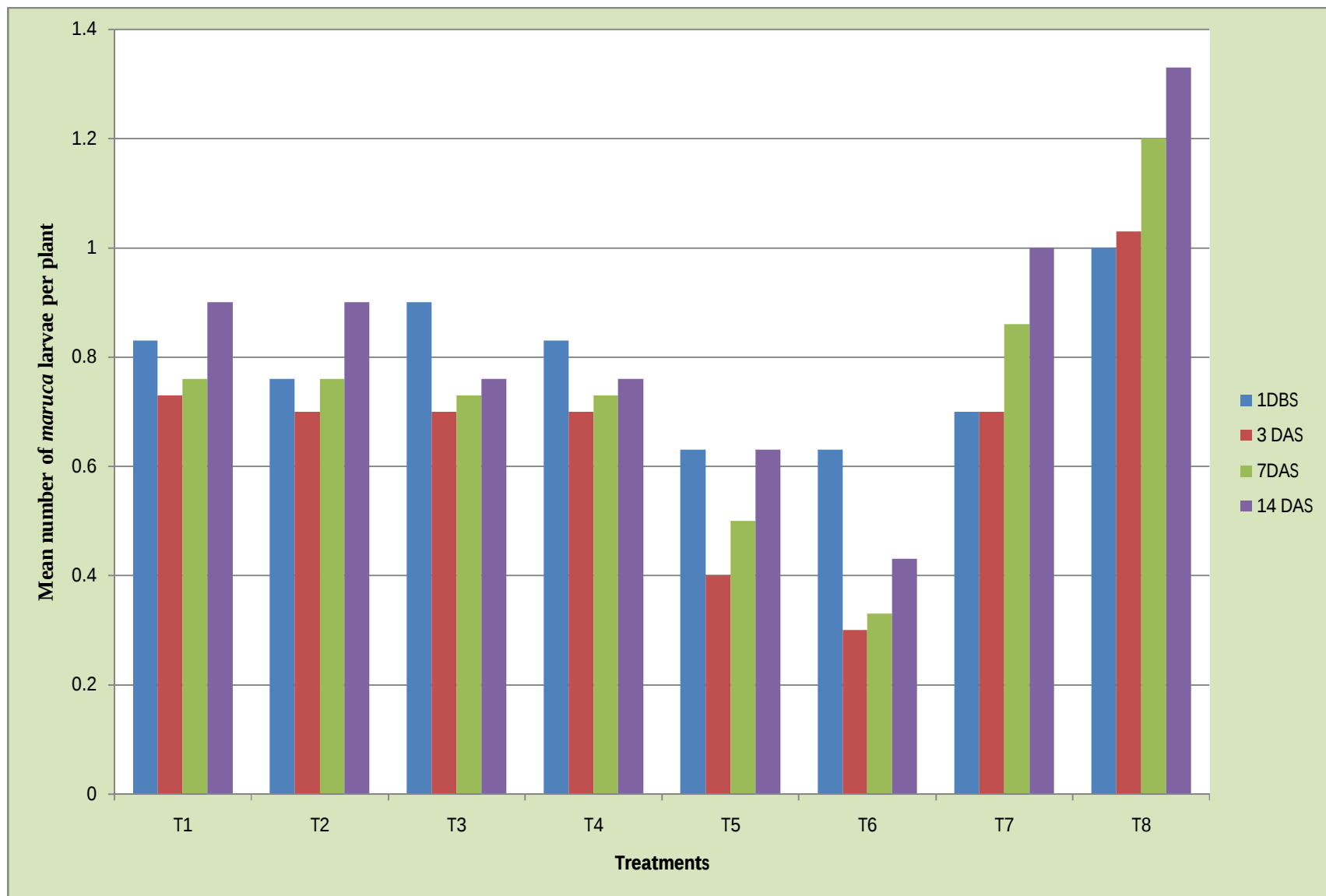
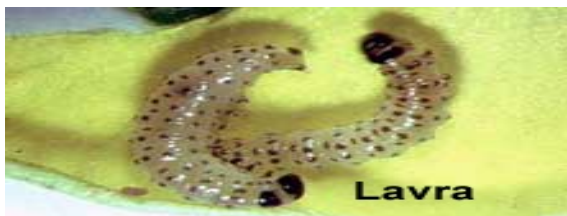


Fig 6 : Efficacy of different insecticides against population of *Maruca vitrata* after third spray.



Spotted pod borer adult



Pod damage by Spotted pod borer

PLATEIII: Incidence of Spotted pod borer

4.1.3 Effect of different insecticides on population of *Exelastis atomosa*

4.1.3.1 First spray: The population of plume moth, *E. atomosa* where not observed during first spray.

4.1.3.2 Second spray

Pre-count one day before second spray

The data on population of *E. atomosa* one day before third spray presented in Table 7 and depicted in Fig. 7. The population of *E. atomosa* ranged between 0.46 to 0.73 larvae / plant. The results were statistically non significant indicating uniform distribution of *E. atomosa* population.

Three day after second spray

The data presented in Table 7 and graphically represented in Fig.7 There were significant differences among the treatments on three days after second spray. All the treatments recorded significantly lower population of *E. atomosa* than untreated control. The population of *E. atomosa* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was recorded lowest (0.26 larvae / plant). which was found statistically significant and at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >Indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.40 larvae / plant). The next best treatment T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.63 larvae /plant) followed by T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.66 larvae / plant), T2 acetamiprid 20SP@20 g.a.i/ha (0.66 larvae /plant), T7 dimethoate 30 EC@600 g.a.i/ha (0.73 larvae /plant) and T₁ acephate 75SP@750 g.a.i/ha (0.73 larvae /plant). The highest population of *Exelastis atomosa* (0.93 larvae /plant) was observed in untreated control.

Seven days after second spray

The data are presented in Table 7 and graphically represented in Fig.7. There was significant differences among the treatments on seven days after second spray. All the treatments recorded significantly lower population of *E. atomosa* than untreated control. The population of *E. atomosa* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was recorded lowest (0.30 larvae / plant). which was found statistically significant and at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.43 larvae / plant). The next best treatment T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.66

larvae / plant) followed by T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.70 larvae / plant), T2 acetamiprid 20SP@20 g.a.i/ha (0.76 larvae /plant), T7 dimethoate 30 EC@600 g.a.i/ha (0.76 larvae /plant) and T₁ acephate 75SP@750 g.a.i/ha (0.80 larvae /plant). The highest population of *Exelastis atomosa* (0.96 larvae /plant) was observed in untreated control.

Fourteen days after second spray

The data presented in Table 7 and graphically represented in Fig.7. There was significant differences among the treatments on fourteen days after second spray. All the treatments recorded significantly lower population of *E. atomosa* than untreated control. The population of *E. atomosa* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was recorded lowest (0.36 larvae / plant). which was found statistically at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.50 larvae / plant). followed by T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.70 larvae / plant), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.73 larvae / plant), T₁ acephate 75SP@750 g.a.i/ha (0.86 larvae / plant) and T7 dimethoate 30 EC@600 g.a.i/ha (0.90 larvae / plant). The highest population of *E. atomosa* (1.13 larvae /plant) was observed in untreated control.

Table 7: Efficacy of different insecticides against population of *Exelastis atomosa* after second spray

Tr. No.	Treatments	Dosages (g.a.i/ha)	Mean number of plume moth larvae per plant			
			1DBS	3 DAS	7DAS	14 DAS
T ₁	Acephate 75 SP @ 0.15 %	750	0.60 (1.05)	0.73 (1.11)	0.80 (1.13)	0.86 (1.16)
T ₂	Acetamiprid 20 SP @ 0.004 %	20	0.46 (0.98)	0.66 (1.08)	0.76 (1.12)	0.80 (1.14)
T ₃	Chlorantraniliprole 18.5%SC >Acephate 75SP	30 750	0.63 (1.06)	0.66 (1.07)	0.70 (1.09)	0.73 (1.11)
T ₄	Chlorantraniliprole 18.5%SC >Acetamiprid 20SP	30 20	0.63 (1.05)	0.63 (1.06)	0.66 (1.08)	0.70 (1.09)
T ₅	Chlorantraniliprole 18.5%SC >Indoxacarb 15.8 EC >Acetamiprid 20 SP	30 73 20	0.50 (1.00)	0.40 (0.95)	0.43 (0.96)	0.50 (1.00)
T ₆	Chlorantraniliprole 18.5%SC >Flubendiamide20WG >Dimethoate 30 EC	30 73 600	0.50 (1.00)	0.26 (0.87)	0.30 (0.89)	0.36 (0.93)
T ₇	Dimethoate 30 EC	600	0.53 (1.02)	0.73 (1.10)	0.76 (1.12)	0.90 (1.18)
T ₈	Untreated Control	-	0.73 (1.11)	0.93 (1.19)	0.96 (1.21)	1.13 (1.27)
	SE ±		0.06	0.06	0.06	0.06
	CD at 5%		NS	0.18	0.18	0.19
	CV		10.53	10.02	10.01	10.28

Figures in parentheses are $\sqrt{x + 0.50}$ transformed value

DBS- Day before spray. DAS - Days after spray.

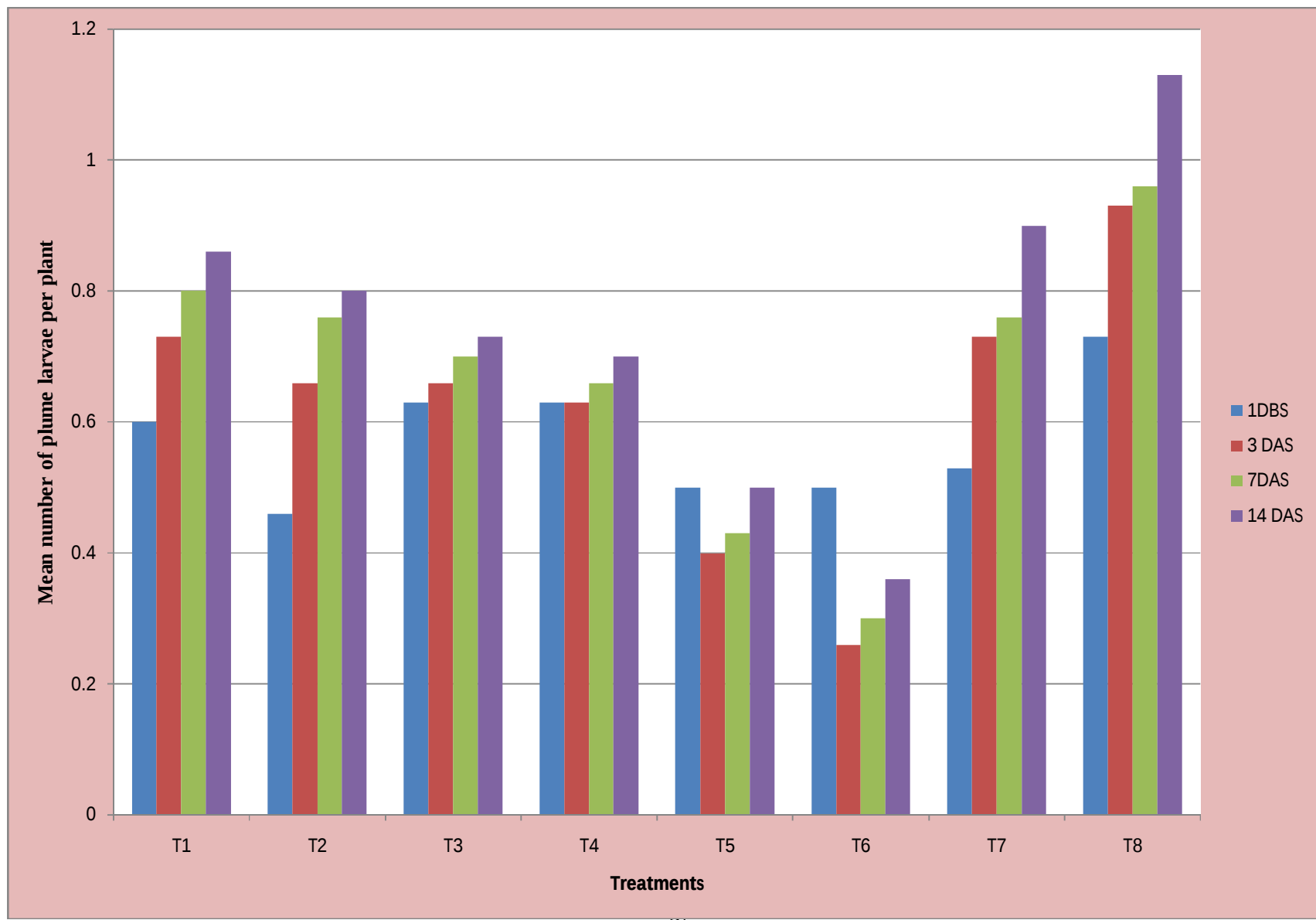


Fig 7: Efficacy of different insecticides against population of *Exelastis atomosa* after second spray.

4.1.3.3 Third spray

Pre-count one day before third spray

The data on population of *E. atomosa* one day before third spray presented in Table 8 and depicted in Fig. 8. The population of *E. atomosa* ranged between 0.46 to 0.86 larvae / plant. The results were statistically non significant indicating uniform distribution of *E. atomosa* population.

Three day after third spray

The data presented in Table 8 and graphically represented in Fig.8. There were significant differences among the treatments on three days after third spray. All the treatments recorded significantly lower population of *E. atomosa* than untreated control. The population of *E. atomosa* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha recorded lowest (0.33 larvae / plant). which was found statistically significant and at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.40 larvae / plant). followed by T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.73 larvae / plant). The next best treatment T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.80 larvae / plant) followed by T2 acetamiprid 20SP@20 g.a.i/ha (0.83 larvae /plant), T₁ acephate 75SP@750 g.a.i/ha (0.86 larvae /plant) and T7 dimethoate 30 EC@600 g.a.i/ha (1.00 larvae /plant) .The highest population of *Exelastis atomosa* (1.13 larvae /plant) was observed in untreated control.

Seven days after third spray

The data presented in Table 8 and graphically represented in Fig.8. There were significant differences among the treatments on seven days after third spray. All the treatments recorded significantly lower population of *E. atomosa* than untreated control. The population of *E. atomosa* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was recorded lowest (0.36 larvae / plant). which was found statistically at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.56 larvae / plant). The next best treatment T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha> acephate75SP@750 g.a.i/ha (0.80 larvae / plant), followed by T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.83 larvae /plant), T2 acetamiprid 20SP@20 g.a.i/ha (0.86 larvae

/plant), T₁ acephate 75SP@750 g.a.i/ha (0.93 larvae /plant) and T7 dimethoate 30 EC@600 g.a.i/ha (1.06 larvae /plant). The highest population of *Exelastis atomosa* (1.30 larvae /plant) was observed in untreated control.

Fourteen days after third spray

The data presented in Table 8 and graphically represented in Fig.8 There were significant differences among the treatments on fourteen days after third spray. All the treatments recorded significantly lower population of *E. atomosa* than untreated control. The population of *E. atomosa* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was recorded lowest (0.43 larvae / plant). which was at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.66 larvae / plant). followed by T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.90 larvae / plant), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.86 larvae / plant), T₁ acephate 75SP@750 g.a.i/ha (0.96 larvae / plant), T7 dimethoate 30 EC@600 g.a.i/ha (1.13 larvae / plant). The highest population of *Exelastis atomosa* (1.43 larvae /plant) was observed in untreated control.

The present investigation shows that chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was superior in controlling plume moth (*E. atomosa*) population. The present study accordance with Satpute and Barkhade *et al.*, (2012) field evaluation of different doses of rynaxypyr 20 SC against the pod borer complex (*H. armigera*, *M. obtusa*, *E. atomosa*) of pigeonpea revealed significant differences among the treatments and the higher doses of rynaxypyr 20 SC (30 and 40g a.i./ha) were found most effective in reducing the pest population. As far as the yield of pigeonpea was concerned, the conventional insecticides were found at par with the higher doses of rynaxypyr 20 SC.

Similarly Singh and Yadav (2005) pod borer viz., *H. armigera* and *E. atomosa* are the major pests in causing economic damage to the pigeonpea crop. Keeping in view, the economic importance of both the pests, an investigation was laid out to assess the bioefficacy of two modern insecticidal molecules i.e., indoxacarb, spinosad, two *Bacillus thuringiensis* based bioinsecticides viz., biolep, halt and their judicious combination during kharif 2004-05. The studies revealed that combination of full dose of indoxacarb with halt (T6) was most effective treatment in reducing pod damage

(9.00%), grain damage (6.48%) and weight loss (5.83%) in pigeonpea crop during both the years.

Table 8: Efficacy of different insecticides against population of *Exelastis atomosa* after third spray

Tr. No.	Treatments	Dosages (g.a.i/ha)	Mean number of plume moth larvae per plant			
			1DBS	3 DAS	7DAS	14 DAS
T ₁	Acephate 75 SP @ 0.15 %	750	0.80 (1.16)	0.86 (1.16)	0.93 (1.19)	0.96 (1.20)
T ₂	Acetamiprid 20 SP @ 0.004 %	20	0.46 (0.98)	0.83 (1.15)	0.86 (1.16)	0.93 (1.19)
T ₃	Chlorantraniliprole 18.5%SC >Acephate 75SP	30 750	0.63 (1.06)	0.80 (1.13)	0.80 (1.15)	0.86 (1.17)
T ₄	Chlorantraniliprole 18.5%SC >Acetamiprid 20SP	30 20	0.63 (1.05)	0.73 (1.11)	0.83 (1.15)	0.90 (1.17)
T ₅	Chlorantraniliprole 18.5%SC >Indoxacarb 15.8 EC >Acetamiprid 20 SP	30 73 20	0.50 (1.00)	0.40 (0.95)	0.56 (1.03)	0.66 (1.08)
T ₆	Chlorantraniliprole 18.5%SC >Flubendiamide20WG >Dimethoate 30 EC	30 73 600	0.53 (1.02)	0.33 (0.91)	0.36 (0.93)	0.43 (0.96)
T ₇	Dimethoate 30 EC	600	0.60 (1.05)	1.00 (1.21)	1.06 (1.24)	1.13 (1.27)
T ₈	Untreated Control	-	0.86 (1.17)	1.13 (1.27)	1.30 (1.34)	1.43 (1.38)
	SE $\pm$		0.06	0.06	0.07	0.07
	CD at 5%		NS	0.20	0.21	0.22
	CV		10.30	10.46	10.61	10.98

Figures in parentheses are $\sqrt{x + 0.50}$ transformed value

DBS- Day before spray. DAS - Days after spray.

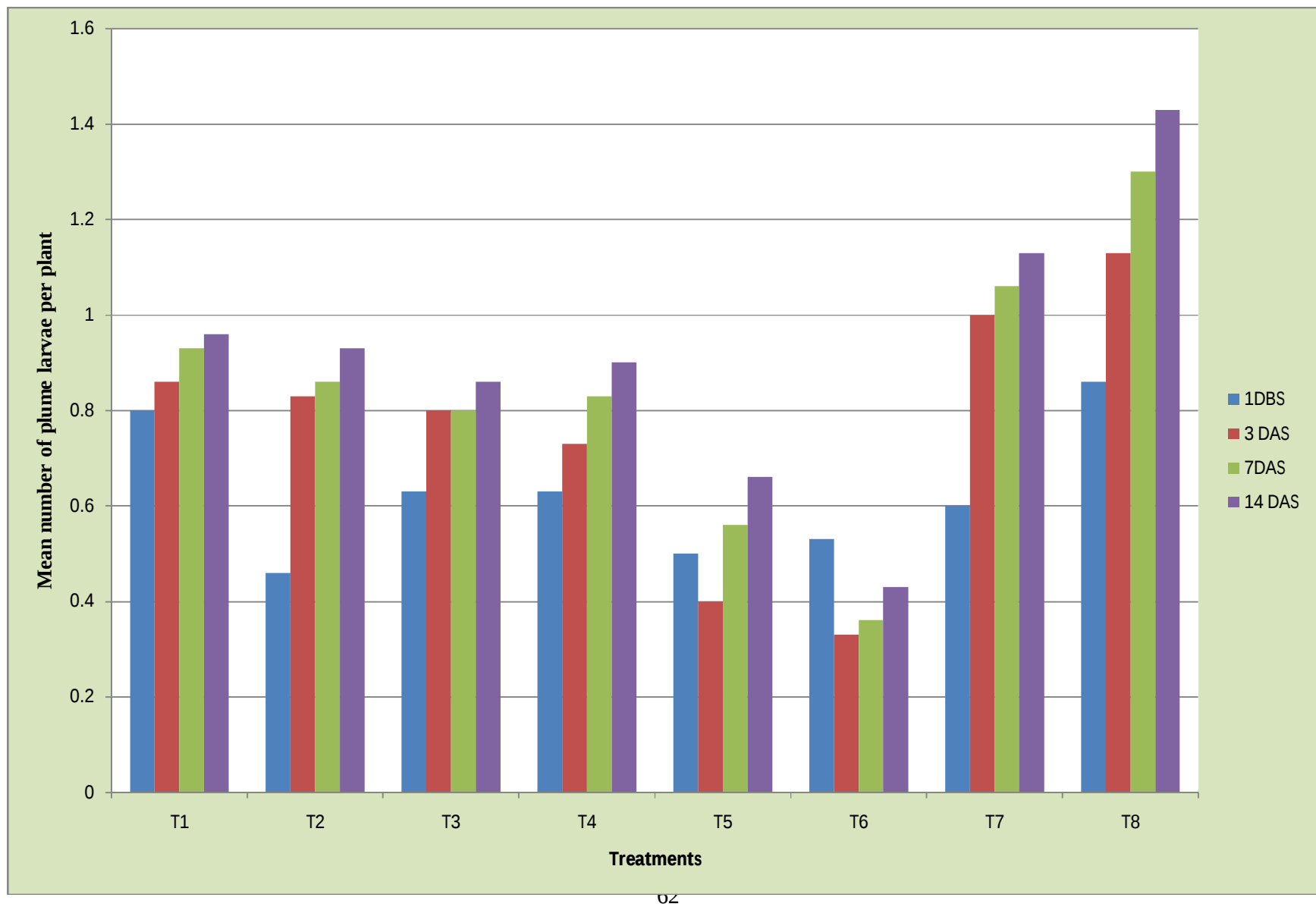


Fig 8: Efficacy of different insecticides against population of *Exelastis atomosa* after third spray



Plume moth larvae



Plume moth adult



Pod damage by plume moth

PLATE IV: Incidence of Plume moth

4.1.4 Effect of different insecticides on population of *Melanagromyza obtusa*

4.1.4.1 First spray: The population of pod fly, *Melanagromyza obtusa* where not observed during first spray.

4.1.4.2 Second spray

Pre-count one day before second spray

The data on population of *M. obtusa* one day before second spray presented in Table 9 and depicted in Fig. 9. The population of *M. obtusa* ranged between 8.33 to 21.66 maggots & pupa / 50 pods. The results were statistically non significant indicating uniform distribution of *M. obtusa* population.

Three days after second spray

The data presented in Table 9 and graphically represented in Fig.9 There were significant differences among the treatments on three days after second spray. All the treatment recorded significantly lower population of *M. obtusa* than untreated control. The population of *M. obtusa* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was recorded lowest (5.00 maggots & pupa / 50 pods). which was found at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (8.33 maggots & pupa / 50 pods). The next best treatment T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (13.33 maggots & pupa / 50 pods) followed by T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (13.33 maggots & pupa / 50 pods), T2 acetamiprid 20SP@20 g.a.i/ha (15.00 maggots & pupa / 50 pods), T7 dimethoate 30 EC@600 g.a.i/ha (16.66 maggots & pupa / 50 pods) and T₁ acephate 75SP@750 g.a.i/ha (18.33 maggots & pupa / 50 pods). The highest population of *Melanagromyza obtusa* (21.66 maggots & pupa / 50 pods) was observed in untreated control.

Seven days after second spray

The data presented in Table 9 and graphically represented in Fig.9. There were significant differences among the treatments on seven days after second spray. All the treatments recorded significantly lower population of *M. obtusa* than untreated control. The population of *M. obtusa* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was recorded

lowest (6.66 maggots & pupa / 50 pods). which was found at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (10.00 maggots & pupa / 50 pods). The next best treatment T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (15.00 maggots & pupa / 50 pods) followed by T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (15.00 maggots & pupa / 50 pods), T2 acetamiprid 20SP@20 g.a.i/ha (16.66 maggots & pupa / 50 pods), T7 dimethoate 30 EC@600 g.a.i/ha (18.33 maggots & pupa / 50 pods) and T₁acephate 75SP@750 g.a.i/ha (20.00 maggots & pupa / 50 pods). The highest population of *Melanagromyza obtusa* (25.00 maggots & pupa / 50 pods) was observed in untreated control.

Fourteen days after second spray

The data presented in Table 9 and graphically represented in Fig.9. There were significant differences among the treatments on fourteen days after second spray. All the treatments recorded significantly lower population of *M. obtusa* than untreated control. The population of *M. obtusa* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was recorded lowest (13.33 maggots & pupa / 50 pods). which was found at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (15.00 maggots & pupa / 50 pods). followed by T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (16.66 maggots & pupa / 50 pods), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (16.66 maggots & pupa / 50 pods), T2 acetamiprid 20SP@20 g.a.i/ha (18.33 maggots & pupa / 50 pods), T7 dimethoate 30 EC@600 g.a.i/ha (20.00 maggots & pupa / 50 pods) and T₁ acephate 75SP@750 g.a.i/ha (20.00 maggots & pupa / 50 pods). The highest population of *M. obtusa* (30.00 maggots & pupa / 50 pods) was observed in untreated control.

Table 9: Efficacy of different insecticides against population of pod fly after second spray

Tr. No.	Treatments	Dosages (g.a.i/ha)	Mean number of maggot per plant			
			1DBS	3 DAS	7DAS	14 DAS
T ₁	Acephate 75 SP @ 0.15 %	750	20.00 (26.07)	18.33 (25.30)	20.00 (26.45)	20.00 (26.56)
T ₂	Acetamiprid 20 SP @ 0.004 %	20	20.00 (26.14)	15.00 (22.59)	16.66 (24.04)	18.33 (25.30)
T ₃	Chlorantraniliprole 18.5%SC >Acephate 75SP	30 750	16.66 (24.04)	13.33 (21.14)	15.00 (22.59)	16.66 (23.74)
T ₄	Chlorantraniliprole 18.5%SC >Acetamiprid 20SP	30 20	15.00 (22.59)	13.33 (21.14)	15.00 (22.59)	16.66 (24.04)
T ₅	Chlorantraniliprole 18.5%SC >Indoxacarb 15.8 EC >Acetamiprid 20 SP	30 73 20	10.00 (18.43)	8.33 (16.59)	10.00 (18.04)	15.00 (22.59)
T ₆	Chlorantraniliprole 18.5%SC >Flubendiamide20WG >Dimethoate 30 EC	30 73 600	8.33 (16.59)	5.00 (12.92)	6.66 (14.76)	13.33 (21.33)
T ₇	Dimethoate 30 EC	600	16.66 (23.74)	16.66 (24.04)	18.33 (25.30)	20.00 (26.45)
T ₈	Untreated Control	-	21.66 (27.59)	21.66 (27.59)	25.00 (29.68)	30.00 (33.16)
	SE $\pm$		2.65	1.98	2.45	1.91
	CD at 5%		NS	5.99	7.41	5.79
	CV		19.84	16.06	18.55	13.08

Figures of percentage in parenthesis are angular transformed values.

DBS- Day before spray. DAS - Days after spray.

4.1.4.3 Third spray

Pre-count one day before third spray

The data of population on *M. obtusa* one day before third spray is presented in Table 10 and depicted in Fig. 10. The population of *M. obtusa* ranged between 16.66 to 28.33 maggots & pupa / 50 pods. The results were statistically non significant indicating uniform distribution of *M. obtusa* population.

Three days after third spray

The data presented in Table 10 and graphically represented in Fig.10 There were significant differences among the treatments three days after third spray. All the treatments recorded significantly lower population of *M. obtusa* than untreated control. The population of *M. obtusa* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was recorded lowest (6.66 maggots & pupa / 50 pods). which was found statistically significant and at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (8.33 maggots & pupa / 50 pods) followed by T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (13.33 maggots & pupa / 50 pods) and T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (13.33 maggots & pupa / 50 pods) The next best treatment T2 acetamiprid 20SP@20 g.a.i/ha (15.00 maggots & pupa / 50 pods), T7 dimethoate 30 EC@600 g.a.i/ha (16.66 maggots & pupa / 50 pods) and T₁ acephate 75SP@750 g.a.i/ha (18.33 maggots & pupa / 50 pods). The highest population of *M. obtusa* (23.33 maggots & pupa / 50 pods) was observed in untreated control.

Seven days after third spray

The data presented in Table 10 and graphically represented in Fig.10 There were significant differences among the treatments on seven days after third spray. All the treatments recorded significantly lower population of *M. obtusa* than untreated control. The population of *M. obtusa* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was recorded lowest (6.66 maggots & pupa / 50 pods). which was found statistically significant and at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (10.00 maggots & pupa / 50 pods). The next best treatment T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid20SP@20 g.a.i/ha (15.00 maggots & pupa / 50 pods) followed by T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (16.66 maggots & pupa / 50

pods), T2 acetamiprid 20SP@20 g.a.i/ha (16.66 maggots & pupa / 50 pods), T7 dimethoate 30 EC@600 g.a.i/ha (16.66 maggots & pupa / 50 pods) and T₁ acephate 75SP@750 g.a.i/ha (18.33 maggots & pupa / 50 pods). The highest population of *M. obtusa* (26.66 maggots & pupa / 50 pods) was observed in untreated control.

Fourteen days after third spray

The data presented in Table 10 and graphically represented in Fig.10 .There were significant differences among the treatments on fourteen days after third spray. All the treatments recorded significantly lower population of *M. obtusa* than untreated control. The population of *M. obtusa* in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was recorded lowest (11.66 maggots & pupa / 50 pods). which was found statistically significant and at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (13.33 maggots & pupa / 50 pods) followed by T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (16.66 maggots & pupa / 50 pods), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (15.00 maggots & pupa / 50 pods), T2 acetamiprid 20SP@20 g.a.i/ha (18.33 maggots & pupa / 50 pods), T7 dimethoate 30 EC@600 g.a.i/ha (18.33 maggots & pupa / 50 pods) and T₁ acephate 75SP@750 g.a.i/ha (20.00 maggots & pupa / 50 pods). The highest population of *M. obtusa* (33.33 maggots & pupa / 50 pods) was observed in untreated control.

The experimental results revealed that chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was effective in controlling Pod fly, (*M. obtuse*) population in all sprays. The Similar results were given by Sreekanth *et al.*, (2014) conducted experiment on efficacy of novel insecticides to control Podfly *Melanagromyza obtuse* affecting pigeonpea they reported that the pod damage due to pod fly was lowest in spinosad 45% SC (10.2%), flubendiamide 480 SC (10.4%), profenophos 50% EC (10.9%) and chlorantraniliprole 20% SC (12.5%) with 76.7, 76.3, 75.1 and 71.5 per cent reduction over control (43.8%) respectively. followed by Wadaskar *et al.*, (2013) conducted experiment on field efficacy of newer insecticides against pod borer complex of pigeonpea and they reported that the reduction of *H. armigera* larval population, 7 and 14 days after the treatment, revealed superiority of Flubendiamide 20 WDG @ 0.5 g /l, which resulted in reduction to the extent of 96.1 and 95.4 per cent, over control, respectively. flubendiamide was also efficacious against plume moth larvae, 7 days and 14 days

application, with 83.9 and 93.3 per cent reduction over control, respectively. The superior treatment effectively restricted the lepidopteran pod borer damage (4.4%), pod damage by pod fly (7.8%) and grain damage by pod fly(6.0%) to minimal, whereas, untreated control plot had 15.9 per cent pod damage due to lepidopteran pod borers, 14.2 per cent pod damage due to pod fly and 11.0 per cent grain damage by pod fly. Treatment with Flubendiamide also translated into realization of highest yield of 13.3 q per ha. As against 8.8 q per ha in untreated control.

Table 10: Efficacy of different insecticides against population of pod fly after third spray

Tr. No.	Treatments	Dosages (g.a.i/ha)	Mean number of maggot per plant			
			1DBS	3 DAS	7DAS	14 DAS
T ₁	Acephate 75 SP @ 0.15 %	750	20.00 (26.14)	18.33 (25.30)	18.33 (25.30)	20.00 (26.45)
T ₂	Acetamiprid 20 SP @ 0.004 %	20	20.00 (26.45)	15.00 (22.59)	16.66 (24.04)	18.33 (25.30)
T ₃	Chlorantraniliprole 18.5%SC >Acephate 75SP	30 750	21.66 (27.52)	13.33 (21.14)	16.66 (23.85)	15.00 (25.00)
T ₄	Chlorantraniliprole 18.5%SC >Acetamiprid 20SP	30 20	20.00 (25.83)	13.33 (21.14)	15.00 (22.59)	16.66 (24.04)
T ₅	Chlorantraniliprole 18.5%SC >Indoxacarb 15.8 EC >Acetamiprid 20 SP	30 73 20	16.66 (23.85)	8.33 (16.59)	10.00 (18.43)	13.33 (21.14)
T ₆	Chlorantraniliprole 18.5%SC >Flubendiamide20WG >Dimethoate 30 EC	30 73 600	20.00 (26.45)	6.66 (14.76)	6.66 (14.76)	11.66 (19.30)
T ₇	Dimethoate 30 EC	600	21.66 (27.59)	16.66 (24.04)	16.66 (24.04)	18.33 (25.30)
T ₈	Untreated Control	-	28.33 (31.93)	23.33 (28.66)	26.66 (30.67)	33.33 (35.11)
	SE $\pm$		2.99	2.26	2.48	2.43
	CD at 5%		NS	6.83	7.49	7.35
	CV		19.23	17.99	18.72	16.73

Figures of percentage in parenthesis are angular transformed values.

DBS- Day before spray. DAS - Days after spray



Pod fly larvae



Pod fly adult

PLATE V: Incidence of Pod fly

4.2: To study the bio-safety of different insecticides against natural enemies.

4.2.1 Effect of different insecticides on population of lady bird beetle

4.2.1.1 First spray

Pre-count one day before first spray

The data on population of lady bird beetle one day before first spray is presented in Table 11 and depicted in Fig. 11. The results were statistically non significant indicating uniform distribution of population. The average number of lady bird beetle range between 0.68 to 1.21 LBB/plant in different insecticidal treatments.

Three day after first spray

The data presented in Table 11 and depicted in Fig. 11. There were non-significant differences among the treatments on three day after first spray. The population of lady bird beetle order of sequence in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (0.52 /plant) followed by T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.36 / plant), T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.28 / plant). T2 acetamiprid 20SP@20 g.a.i/ha (0.28 /plant), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.27 / plant), T₁ acephate 75SP@750 g.a.i/ha (0.20 /plant) and T7 dimethoate 30 EC@600 g.a.i/ha (0.15 /plant) were recorded similar trend .The highest population of lady bird beetle (0.65 / plant) was observed in untreated control.

Seven days after first spray

The data recorded seven day after first spray Table 11 and depicted in Fig. 11. There were non-significant differences among the treatments on seven day after first spray. where all the treatments recorded lower population of lady bird beetle compare to untreated control. The population of lady bird beetle in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (0.68 /plant) as higher T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.62 / plant), T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.55 / plant). T2 acetamiprid 20SP@20 g.a.i/ha (0.55/plant), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.40 / plant), T₁ acephate 75SP@750 g.a.i/ha (0.27 /plant) and T7 dimethoate 30 EC@600 g.a.i/ha

(0.37 /plant) show similar trend. The highest population of lady bird beetle (0.89 / plant) was observed in untreated control.

Fourteen days after first spray

The data presented in Table 11 and depicted in Fig. 11. There were non significant differences among the treatments on fourteen days after first spray. where all the treatments were recorded lower population of lady bird beetle than untreated control. The population of lady bird beetle was maximum in sequence T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (0.95 /plant) were higher followed by T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.82 / plant), T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.62 / plant). The next best treatment are T2 acetamiprid 20SP@20 g.a.i/ha (0.55/plant), T₁ acephate 75SP@750 g.a.i/ha (0.46 /plant) T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.40 / plant) and T7 dimethoate 30 EC@600 g.a.i/ha (0.37 /plant) .The highest population of lady bird beetle (1.12 / plant) was observed in untreated control.

Table 11: Population of Lady bird beetle per plant in Pigeonpea before and after first spray

Tr No.	Treatments	Dosages (g.a.i/ha)	Mean number of lady bird beetle per plants			
			1DBS	3 DAS	7DAS	14 DAS
T ₁	Acephate 75 SP @ 0.15 %	750	0.79 (1.13)	0.20 (0.84)	0.27 (0.88)	0.46 (0.98)
T ₂	Acetamiprid 20 SP @ 0.004 %	20	0.68 (1.09)	0.28 (0.88)	0.55 (1.02)	0.55 (1.02)
T ₃	Chlorantraniliprole 18.5%SC >Acephate 75SP	30 750	0.82 (1.15)	0.27 (0.88)	0.40 (0.93)	0.40 (0.93)
T ₄	Chlorantraniliprole 18.5%SC >Acetamiprid 20SP	30 20	0.87 (1.13)	0.28 (0.88)	0.55 (1.02)	0.62 (1.06)
T ₅	Chlorantraniliprole 18.5%SC >Indoxacarb 15.8 EC >Acetamiprid 20 SP	30 73 20	0.75 (1.12)	0.36 (0.93)	0.62 (1.06)	0.82 (1.15)
T ₆	Chlorantraniliprole 18.5%SC >Flubendiamide20WG >Dimethoate 30 EC	30 73 600	1.06 (1.25)	0.52 (1.01)	0.68 (1.09)	0.95 (1.20)
T ₇	Dimethoate 30 EC	600	0.82 (1.15)	0.15 (0.81)	0.37 (0.92)	0.37 (0.92)
T ₈	Untreated Control	-	1.21 (1.30)	0.65 (1.05)	0.89 (1.17)	1.12 (1.22)
	SE ±		0.09	0.06	0.06	0.10
	CD at 5%		NS	NS	NS	NS
	CV		13.42	13.08	10.77	17.88

Figures in parentheses are $\sqrt{x + 0.50}$ transformed value

DBS- Day before spray. DAS - Days after spray.

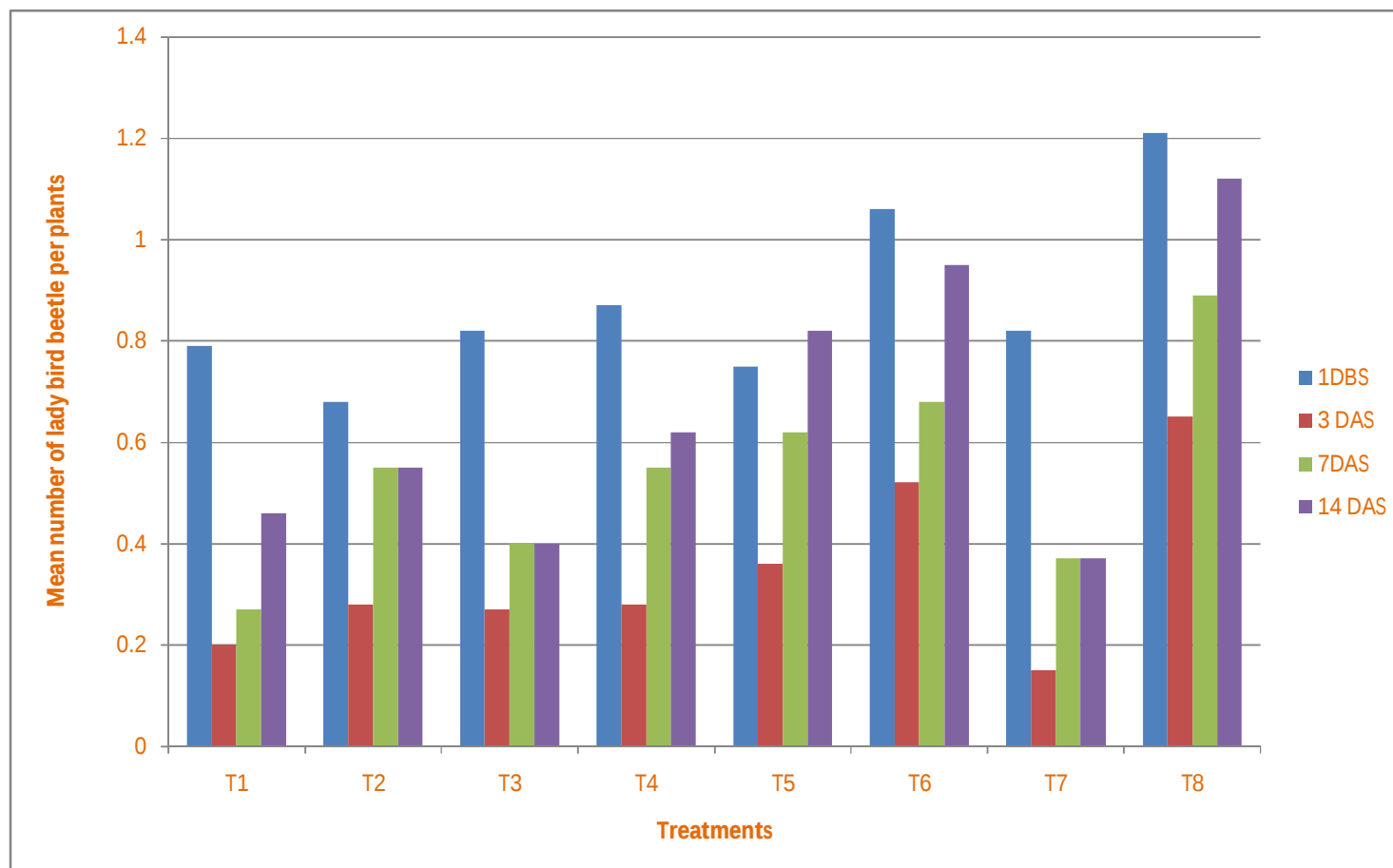


Fig : 11 Effect of different Insecticides against population of lady bird beetle (first spray)

4.2.1.2 Second spray

Pre-count one day before second spray

The data of population on lady bird beetle one day before second spray is presented in Table 12 and depicted in Fig. 12. The results were statistically non significant indicating uniform distribution of predators population. The average number of lady bird beetle range between 0.24 to 0.42 /plant in different insecticidal treatments.

Three day after second spray

The data presented in Table 12 and depicted in Fig. 12. There were non-significant differences among the treatments on three day after second spray. The population of lady bird beetle in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (0.35 /plant) was higher followed by T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.32 / plant), T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.27 / plant). T2 acetamiprid 20SP@20 g.a.i/ha (0.25 /plant), T₁ acephate 75SP@750 g.a.i/ha (0.22 /plant) T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.20 / plant) and T7 dimethoate 30 EC@600 g.a.i/ha (0.15 /plant) were recorded similar trend. The highest population of lady bird beetle (0.70 / plant) was observed in untreated control.

Seven days after second spray

The data presented in Table 12 and depicted in Fig. 12. There were non-significant differences among the treatments on seven day after second spray. The population of lady bird beetle in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (0.55 /plant) was higher followed by T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.51 / plant), T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.48 / plant). T2 acetamiprid 20SP@20 g.a.i/ha (0.46 /plant), T₁ acephate 75SP@750 g.a.i/ha (0.27 /plant) T7 dimethoate 30 EC@600 g.a.i/ha (0.27 /plant) and T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.20 / plant) were recorded population. The highest population of lady bird beetle (1.00 / plant) was observed in untreated control.

Fourteen days after second spray

The data are presented in Table 12 and depicted in Fig. 12. There were non-significant differences among the treatments on fourteen day after second spray. where all the treatments were recorded lower population of lady bird beetle than untreated control. population of lady bird beetle in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (0.82 /plant) were higher followed by T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.78 / plant), T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.75 / plant). T2 acetamiprid 20SP@20 g.a.i/ha (0.68 /plant), T₁ acephate 75SP@750 g.a.i/ha (0.48 /plant) T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.48 / plant) and T7 dimethoate 30 EC@600 g.a.i/ha (0.48 /plant) . The highest population of lady bird beetle (1.34 / plant) was observed in untreated control.

Table 12: Population of Lady bird beetle per plant in Pigeonpea before and after second spray.

Tr No.	Treatments	Dosages (g.a.i/ha)	Mean number of lady bird beetle per plants			
			1DBS	3 DAS	7DAS	14 DAS
T ₁	Acephate 75 SP @ 0.15 %	750	0.24 (0.85)	0.22 (0.85)	0.27 (0.88)	0.48 (0.99)
T ₂	Acetamiprid 20 SP @ 0.004 %	20	0.31 (0.89)	0.25 (0.87)	0.46 (0.98)	0.68 (1.09)
T ₃	Chlorantraniliprole 18.5%SC >Acephate 75SP	30 750	0.28 (0.87)	0.20 (0.83)	0.20 (0.83)	0.48 (0.99)
T ₄	Chlorantraniliprole 18.5%SC >Acetamiprid 20SP	30 20	0.27 (0.88)	0.27 (0.88)	0.48 (0.99)	0.75 (1.12)
T ₅	Chlorantraniliprole 18.5%SC >Indoxacarb 15.8 EC >Acetamiprid 20 SP	30 73 20	0.35 (0.92)	0.32 (0.91)	0.51 (1.00)	0.78 (1.13)
T ₆	Chlorantraniliprole 18.5%SC >Flubendiamide20WG >Dimethoate 30 EC	30 73 600	0.35 (0.92)	0.35 (0.92)	0.55 (1.02)	0.82 (1.15)
T ₇	Dimethoate 30 EC	600	0.28 (0.87)	0.15 (0.81)	0.27 (0.88)	0.48 (0.99)
T ₈	Untreated Control	-	0.42 (0.96)	0.70 (1.07)	1.00 (1.18)	1.34 (1.32)
	SE ±		0.06	0.06	0.08	0.07
	CD at 5%		NS	NS	NS	NS
	CV		12.40	11.93	15.12	12.05

Figures in parentheses are $\sqrt{x + 0.50}$ transformed value

DBS- Day before spray. DAS - Days after spray.

4.2.1.3 Third spray

Pre-count one day before third spray

The data on population on lady bird beetle one day before third spray is presented in Table 13 and depicted in Fig. 13. The results were statistically non significant indicating uniform distribution of predators population. The average number of lady bird beetle ranged from 0.15 to 0.52 /plant in different insecticidal treatments.

Three day after third spray

The data presented in Table 13 and depicted in Fig. 13. There were non-significant differences among the treatments on three day after third spray. The population of lady bird beetle in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (0.17 /plant) was higher followed by T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.15 / plant), T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.13 / plant), T2 acetamiprid 20SP@20 g.a.i/ha (0.11 /plant), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.09 / plant), T1 acephate 75SP@750 g.a.i/ha (0.08 /plant) and T7 dimethoate 30 EC@600 g.a.i/ha (0.08 /plant) . The highest population of lady bird beetle (0.50 / plant) was observed in untreated control.

Seven days after third spray

The data presented in Table 13 and depicted in Fig. 13. There were non-significant differences among the treatments on seven day after third spray. the Population of lady bird beetle in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (0.42 /plant) was higher followed by T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.25 / plant), T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.22 / plant). T2 acetamiprid 20SP@20 g.a.i/ha (0.20 /plant), T7 dimethoate 30 EC@600 g.a.i/ha (0.12 /plant) T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.11 / plant) and T1 acephate 75SP@750 g.a.i/ha (0.08 /plant). The highest population of lady bird beetle (0.75 / plant) was observed in untreated control.

Fourteen days after third spray

The data are presented in Table 13 and depicted in Fig. 13. There were non-significant differences among the treatments on fourteen days after third spray. population of lady bird beetle in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (0.82 /plant) was higher followed by T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.75 / plant), T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.68 / plant). T2 acetamiprid 20SP@20 g.a.i/ha (0.62 /plant),T1 acephate 75SP@750 g.a.i/ha (0.88 /plant), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.42 / plant) and T7 dimethoate 30 EC@600 g.a.i/ha (0.40 /plant). The highest population of lady bird beetle (0.93 / plant) was observed in untreated control.

The experimental results obtained shows that T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was less toxic to lady bird beetle. the similar results are also reported by, Ameta *et al.*, (2010b) All the doses of flubendiamide 480SC reported safe to lady bird beetles and Chrysoperla. Dhawan *et al.*, (2009) reported that chlorantraniliprole 20 SC @ 30 g ai/ha was the most effective treatment for the control of bollworm complex on cotton as it did not cause any resurgence in sucking pests and was also safer to natural enemies. and Thilagam *et al.*, (2011) reported that flubendiamide 480 SC @ 36 and 48 g a.i/ha to be least toxic to spiders, coccinellids and Chrysoperla population on cotton. However, these populations were affected initially till seven days of application but the population showed increasing trend thereafter.

Table 13: Population of Lady bird beetle per plant in Pigeonpea before and after third spray.

Tr No.	Treatments	Dosages (g.a.i/ha)	Mean number of lady bird beetle per plants			
			1DBS	3 DAS	7DAS	14 DAS
T ₁	Acephate 75 SP @ 0.15 %	750	0.15 (0.81)	0.08 (0.76)	0.08 (0.76)	0.88 (0.99)
T ₂	Acetamiprid 20 SP @ 0.004 %	20	0.31 (0.89)	0.11 (0.78)	0.20 (0.84)	0.62 (1.06)
T ₃	Chlorantraniliprole 18.5%SC >Acephate 75SP	30 750	0.15 (0.81)	0.09 (0.77)	0.11 (0.78)	0.42 (0.96)
T ₄	Chlorantraniliprole 18.5%SC >Acetamiprid 20SP	30 20	0.27 (0.88)	0.13 (0.79)	0.22 (0.85)	0.68 (1.09)
T ₅	Chlorantraniliprole 18.5%SC >Indoxacarb 15.8 EC >Acetamiprid 20 SP	30 73 20	0.22 (0.85)	0.15 (0.81)	0.25 (0.86)	0.75 (1.12)
T ₆	Chlorantraniliprole 18.5%SC >Flubendiamide20WG >Dimethoate 30 EC	30 73 600	0.35 (0.92)	0.17 (0.80)	0.42 (0.96)	0.82 (1.15)
T ₇	Dimethoate 30 EC	600	0.27 (0.88)	0.08 (0.76)	0.12 (0.78)	0.40 (0.95)
T ₈	Untreated Control	-	0.52 (0.99)	0.50 (0.99)	0.75 (1.02)	0.93 (1.15)
	SE ±		0.05	0.05	0.07	0.08
	CD at 5%		NS	NS	NS	NS
	CV		10.37	11.90	14.03	13.93

Figures in parentheses are $\sqrt{x + 0.50}$ transformed value

DBS- Day before spray. DAS - Days after spray.

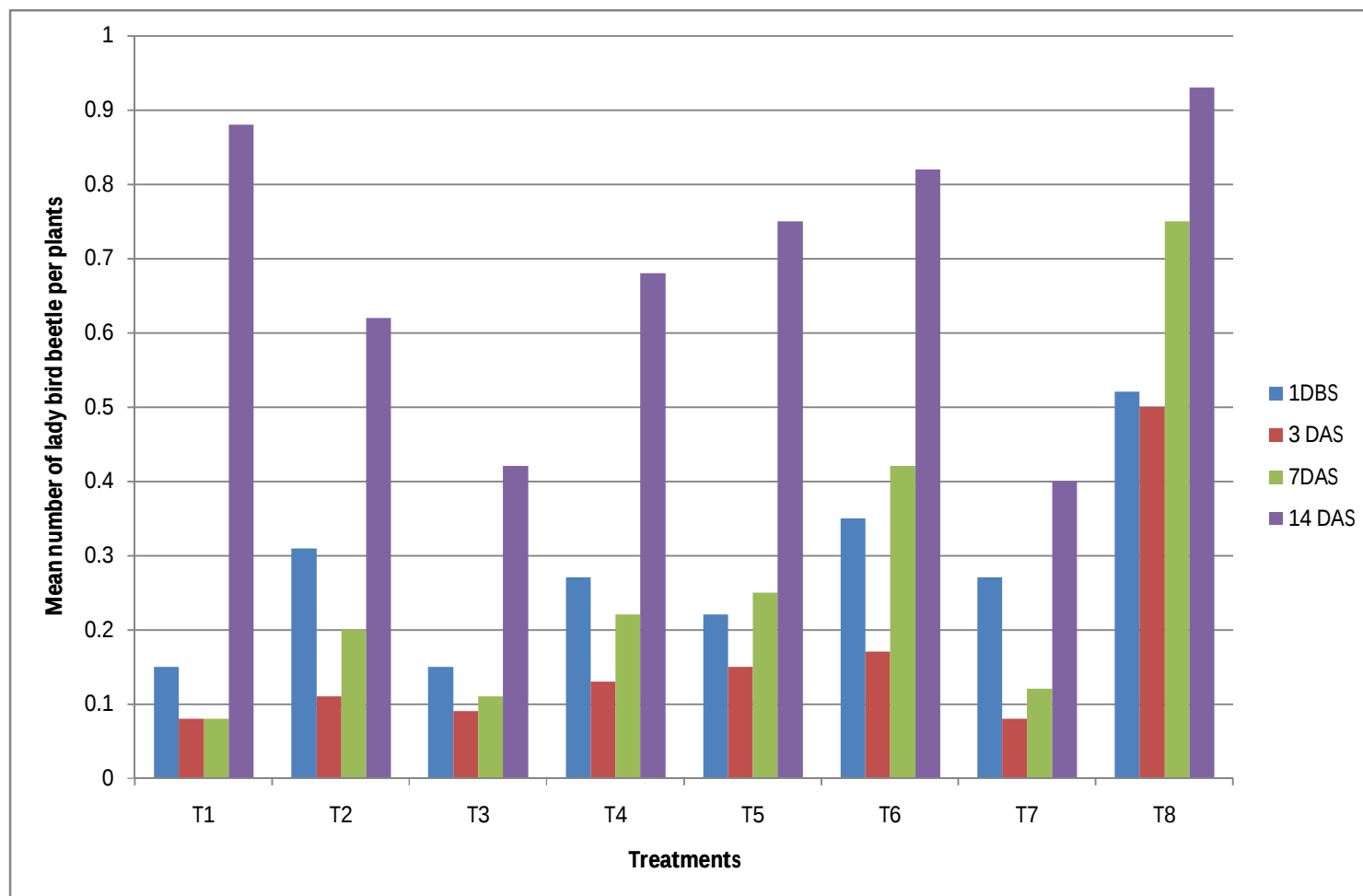


Fig : 13 Effect of different Insecticides on population of Lady bird beetle (third spray).

4.2.2 Effect of different insecticides on population of spider

4.2.2.1 First spray

Pre-count one day before first spray

The data on population of spider one day before first spray is presented in Table 14 and depicted in Fig. 14. The results were statistically non significant indicating uniform distribution of predators population. The average number of spider range between 0.27 to 0.68 /plant in different insecticidal treatments.

Three day after first spray

The data are presented in Table 14 and depicted in Fig. 14. There were non-significant differences among the treatments on three day after first spray in between range 0.21 to 0.56/plant .the population of spider in T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.43 / plant) was higher followed by T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (0.31 /plant), T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.29 / plant), T2 acetamiprid 20SP@20 g.a.i/ha (0.26 /plant), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.26 / plant) T1 acephate 75SP@750 g.a.i/ha (0.22 /plant) and T7 dimethoate 30 EC@600 g.a.i/ha (0.21 /plant). The highest population of spider (0.56 / plant) was observed in untreated control.

Seven day after first spray

The data presented in Table 14 and depicted in Fig. 14. There were non-significant differences among the treatments on seven day after first spray in between range 0.74 to 1.12. the population of spider in T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.92 / plant),was higher followed by T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (0.87 /plant) T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.87 / plant). T2 acetamiprid 20SP@20 g.a.i/ha (0.85 /plant), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.78 / plant) T1 acephate 75SP@750 g.a.i/ha (0.76 /plant) and T7 dimethoate 30 EC@600 g.a.i/ha (0.74 /plant) and. The highest population of lady bird beetle (1.12 / plant) was observed in untreated control.

Fourteen days after first spray

The data presented in Table 14 and depicted in Fig. 14. There were non-significant differences among the treatments on fourteen day after first spray in between range 0.67 to 1.25. The population of spider in T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha > indoxacarb 15.8 EC@73 g.a.i/ha > acetamiprid 20 SP@20 g.a.i/ha (0.96 / plant) was higher followed by T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha > flubendiamide 20WG@73 g.a.i/ha > dimethoate 30 EC@600 g.a.i/ha (0.90 /plant), T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha > acetamiprid 20SP@20 g.a.i/ha (0.87 / plant). T2 acetamiprid 20SP@20 g.a.i/ha (0.86 /plant), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha > acephate 75SP@750 g.a.i/ha (0.73 / plant) and T7 dimethoate 30 EC@600 g.a.i/ha (0.69 /plant), T1 acephate 75SP@750 g.a.i/ha (0.67 /plant). The highest population of spider (1.25 / plant) was observed in untreated control.

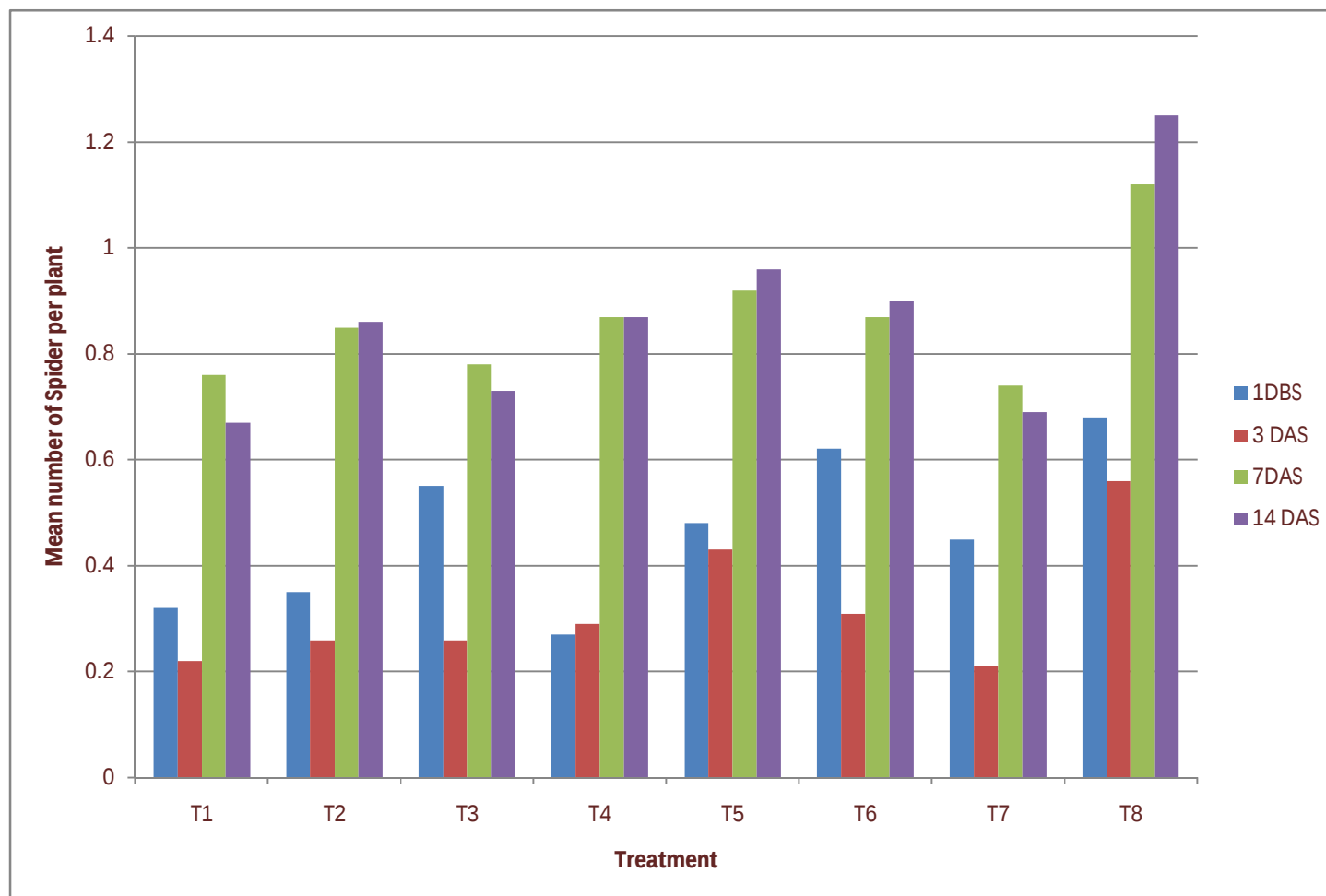


Fig : 14 Effect of different Insecticides on population of spider (first spray).

Table 14: Population of spider per plant in Pigeonpea before and after first spray.

Tr. No.	Treatments	Dosages (g.a.i/ha)	Mean number of Spider per plant			
			1DBS	3 DAS	7DAS	14 DAS
T ₁	Acephate 75 SP @ 0.15 %	750	0.32 (0.89)	0.22 (0.85)	0.76 (1.12)	0.67 (1.08)
T ₂	Acetamiprid 20 SP @ 0.004 %	20	0.35 (0.92)	0.26 (0.87)	0.85 (1.16)	0.86 (1.17)
T ₃	Chlorantraniliprole 18.5%SC >Acephate 75SP	30 750	0.55 (1.02)	0.26 (0.87)	0.78 (1.13)	0.73 (1.11)
T ₄	Chlorantraniliprole 18.5%SC >Acetamiprid 20SP	30 20	0.27 (0.88)	0.29 (0.89)	0.87 (1.17)	0.87 (1.17)
T ₅	Chlorantraniliprole 18.5%SC >Indoxacarb 15.8 EC >Acetamiprid 20 SP	30 73 20	0.48 (0.99)	0.43 (0.97)	0.92 (1.19)	0.96 (1.21)
T ₆	Chlorantraniliprole 18.5%SC >Flubendiamide20WG >Dimethoate 30 EC	30 73 600	0.62 (1.06)	0.31 (0.89)	0.87 (1.17)	0.90 (1.18)
T ₇	Dimethoate 30 EC	600	0.45 (0.95)	0.21 (0.84)	0.74 (1.11)	0.69 (1.09)
T ₈	Untreated Control	-	0.68 (1.09)	0.56 (1.01)	1.12 (1.22)	1.25 (1.26)
	SE ±		0.05	0.07	0.09	0.09
	CD at 5%		NS	NS	NS	NS
	CV		10.59	13.53	14.56	14.79

Figures in parentheses are $\sqrt{x + 0.50}$ transformed value

DBS- Day before spray. DAS - Days after spray.

4.2.2.2 Second spray

Pre-count one day before second spray

The data on population of spider one day before second spray is presented in Table 15 and depicted in Fig. 15. The results were statistically non significant indicating uniform distribution of predators population. The average number of spider range between 0.16 to 0.64 / plant in different insecticidal treatments.

Three days after second spray

The data are presented in Table 15 and depicted in Fig. 15. There were non-significant differences among the treatments on three day after second spray in between range 0.53 to 0.20. The population of spider in T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.89 / plant) was higher followed by T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (0.73 /plant), T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.67 / plant), T2 acetamiprid 20SP@20 g.a.i/ha (0.65 /plant), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.56 / plant) T1 acephate 75SP@750 g.a.i/ha (0.53 /plant) and T7 dimethoate 30 EC@600 g.a.i/ha (0.51/plant). The highest population of spider (1.22 / plant) was observed in untreated control.

Seven day after second spray

The data are presented in Table 15 and depicted in Fig. 15. There were non-significant differences among the treatments on seven day after second spray in between range 0.24 to 1.07. The population of spider in T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.89 / plant) was higher followed by T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (0.63 /plant) , T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.60 / plant), T2 acetamiprid 20SP@20 g.a.i/ha (0.40 /plant), T1 acephate 75SP@750 g.a.i/ha (0.35 /plant), T7 dimethoate 30 EC@600 g.a.i/ha (0.28 /plant) and T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.24 / plant). The highest population of lady bird beetle (1.07 / plant) was observed in untreated control.

Fourteen days after second spray

The data are presented in Table 15 and depicted in Fig. 15. There were non-significant differences among the treatments on fourteen day after second spray in

between range 0.67 to 1.25. The population of spider in T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (1.03 / plant) was higher followed by T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (0.92 /plant), T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.89 / plant), T2 acetamiprid 20SP@20 g.a.i/ha (0.85 /plant), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.69 / plant) and T7 dimethoate 30 EC@600 g.a.i/ha (0.69 /plant), T1 acephate 75SP@750 g.a.i/ha (0.67 /plant). The highest population of spider (1.25 / plant) was observed in untreated control.

Table 15: Population of spider per plant in Pigeonpea before and after second spray.

Tr No.	Treatments	Dosages (g.a.i/ha)	Mean number of Spider per plant			
			1DBS	3 DAS	7DAS	14 DAS
T ₁	Acephate 75 SP @ 0.15 %	750	0.30 (0.88)	0.53 (1.02)	0.35 (0.92)	0.67 (1.08)
T ₂	Acetamiprid 20 SP @ 0.004 %	20	0.16 (0.81)	0.65 (1.07)	0.40 (0.95)	0.85 (1.16)
T ₃	Chlorantraniliprole 18.5%SC >Acephate 75SP	30 750	0.24 (0.86)	0.56 (1.03)	0.24 (0.86)	0.69 (1.09)
T ₄	Chlorantraniliprole 18.5%SC >Acetamiprid 20SP	30 20	0.16 (0.81)	0.67 (1.08)	0.60 (1.05)	0.89 (1.18)
T ₅	Chlorantraniliprole 18.5%SC >Indoxacarb 15.8 EC >Acetamiprid 20 SP	30 73 20	0.28 (0.88)	0.89 (1.18)	0.89 (1.18)	1.03 (1.24)
T ₆	Chlorantraniliprole 18.5%SC >Flubendiamide20WG >Dimethoate 30 EC	30 73 600	0.35 (0.92)	0.73 (1.11)	0.63 (1.06)	0.92 (1.19)
T ₇	Dimethoate 30 EC	600	0.44 (0.95)	0.51 (1.00)	0.28 (0.88)	0.69 (1.09)
T ₈	Untreated Control	-	0.64 (1.07)	1.22 (1.26)	1.07 (1.20)	1.25 (1.26)
	SE ±		0.05	0.08	0.08	0.09
	CD at 5%		NS	NS	NS	NS
	CV		11.44	14.16	14.57	14.71

Figures in parentheses are $\sqrt{x + 0.50}$ transformed value

DBS- Day before spray. DAS - Days after spray.

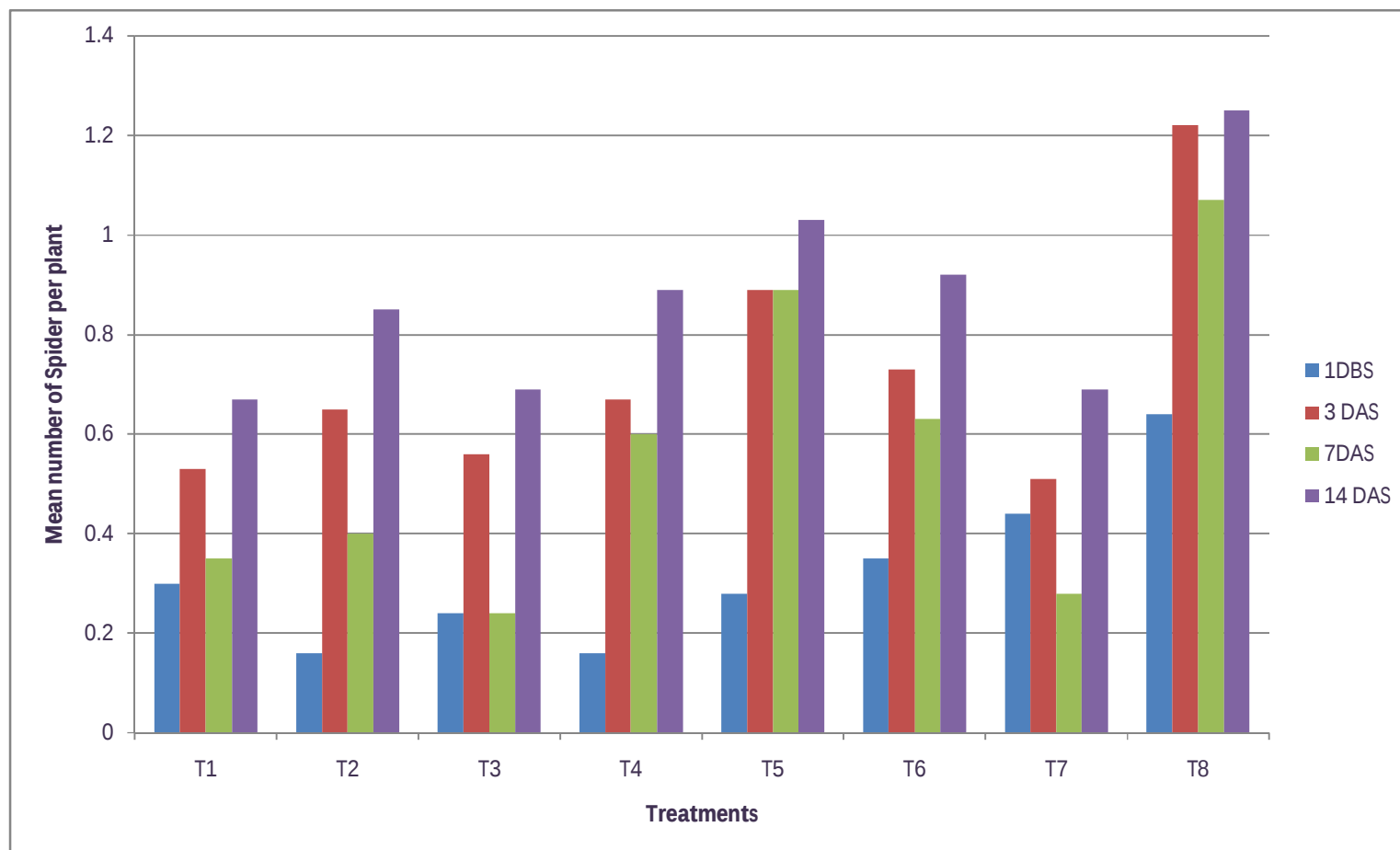


Fig :15 Effect of different Insecticides on population of spider (second spray).

4.2.2.3 Third spray

Pre-count one day before third spray

The data of population on spider one day before third spray is presented in Table 16 and depicted in Fig. 16. The results were statistically non significant indicating uniform distribution of predators population. The average number of spider range between 0.00 to 0.63 /plant in different insecticidal treatments.

Three days after third spray

The data presented in Table 16 and depicted in Fig. 16. Indicated that there were non-significant differences among the treatments on three day after third spray in between range 0.20 to 0.53. The population of spider in T1 acephate 75SP@750 g.a.i/ha (0.53 /plant) followed by T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.44 / plant) T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (0.26 /plant), T2 acetamiprid 20SP@20 g.a.i/ha (0.26 /plant), T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.24 / plant), T7 dimethoate 30 EC@600 g.a.i/ha (0.22/plant) T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.20 / plant). The population of spider (0.40 / plant) was observed in untreated control.

Seven day after third spray

The data presented in Table 16 and depicted in Fig. 16. There were non-significant differences among the treatments on seven days after third spray in between range 0.27 to 1.07. The population of spider in T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.88 / plant) was higher followed by T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (0.55 /plant) , T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.49 / plant). T2 acetamiprid 20SP@20 g.a.i/ha (0.49 /plant), T1 acephate 75SP@750 g.a.i/ha (0.44 /plant), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.35 / plant), T7 dimethoate 30 EC@600 g.a.i/ha (0.27 /plant) . The highest population of spider (1.07 / plant) was observed in untreated control.

Fourteen days after third spray

The data presented in Table 16 and depicted in Fig. 16. There were non-significant differences among the treatments on fourteen day after third spray in between range 0.37 to 1.12. The population of spider in T5 chlorantraniliprole

18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (0.95 / plant) was higher followed by T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (0.82 /plant), T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (0.62 / plant), T2 acetamiprid 20SP@20 g.a.i/ha (0.55 /plant), T1 acephate 75SP@750 g.a.i/ha (0.46 /plant), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (0.40 / plant) and T7 dimethoate 30 EC@600 g.a.i/ha (0.37/plant). The highest population of spider (1.12 / plant) was observed in untreated control.

The experimental results obtained shows that T5 chlorantraniliprole 18.5%SC @30 g.a.i/ha > indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha was less toxic to spider the similar results are also reported by, *Ameta et al.*, (2011) reported evaluated relative efficacy of flubendiamide 480 SC at50, 75 and 100 ml/ha along with indoxacarb 14.5 SC at 500 ml a.i./ha and spinosad 45 SC at 187.5 ml a.i./ha against pigeonpea pod borer viz. *H. armigera* (Hubner) and *M. testulalis* (L.)and was found that flubendiamide 480 SCat100 ml/ha caused significantly high reduction in larvae, recorded minimum flower and pod damage and significantly high seed yield. Insecticidal treatments did not cause adverse effect on population on natural enemies in pigeonpea. Seal *et al.*, (2007) reported that predatory spider population was considerably lowered immediately following application of insecticides such as metaflumiazone, indoxacarb, novaluron, spinetoram and spinosad but the populations treated with indoxacarb and spinosad had fully recovered by the seven days after treatment.

Table 16: Population of spider per plant in Pigeonpea before and after third spray.

Tr No.	Treatments	Dosages (g.a.i/ha)	Mean number of Spider per plant			
			1DBS	3 DAS	7DAS	14 DAS
T ₁	Acephate 75 SP @ 0.15 %	750	0.30 (0.88)	0.53 (1.03)	0.44 (0.97)	0.46 (0.98)
T ₂	Acetamiprid 20 SP @ 0.004 %	20	0.19 (0.83)	0.26 (0.87)	0.49 (0.99)	0.55 (1.02)
T ₃	Chlorantraniliprole 18.5%SC >Acephate 75SP	30 750	0.35 (0.92)	0.20 (0.84)	0.35 (0.92)	0.40 (0.93)
T ₄	Chlorantraniliprole 18.5%SC >Acetamiprid 20SP	30 20	0.15 (0.80)	0.24 (0.86)	0.49 (1.00)	0.62 (1.06)
T ₅	Chlorantraniliprole 18.5%SC >Indoxacarb 15.8 EC >Acetamiprid 20 SP	30 73 20	0.34 (0.91)	0.44 (0.97)	0.88 (1.17)	0.95 (1.20)
T ₆	Chlorantraniliprole 18.5%SC >Flubendiamide20WG >Dimethoate 30 EC	30 73 600	0.45 (0.97)	0.26 (0.87)	0.55 (1.03)	0.82 (1.15)
T ₇	Dimethoate 30 EC	600	0.00 (0.71)	0.22 (0.85)	0.27 (0.88)	0.37 (0.92)
T ₈	Untreated Control	-	0.63 (1.03)	0.40 (0.91)	1.07 (1.20)	1.12 (1.22)
	SE ±		0.06	0.07	0.08	0.09
	CD at 5%		NS	NS	NS	NS
	CV		12.58	14.24	14.66	15.99

Figures in parentheses are $\sqrt{x + 0.50}$ transformed value

DBS- Day before spray. DAS - Days after spray.

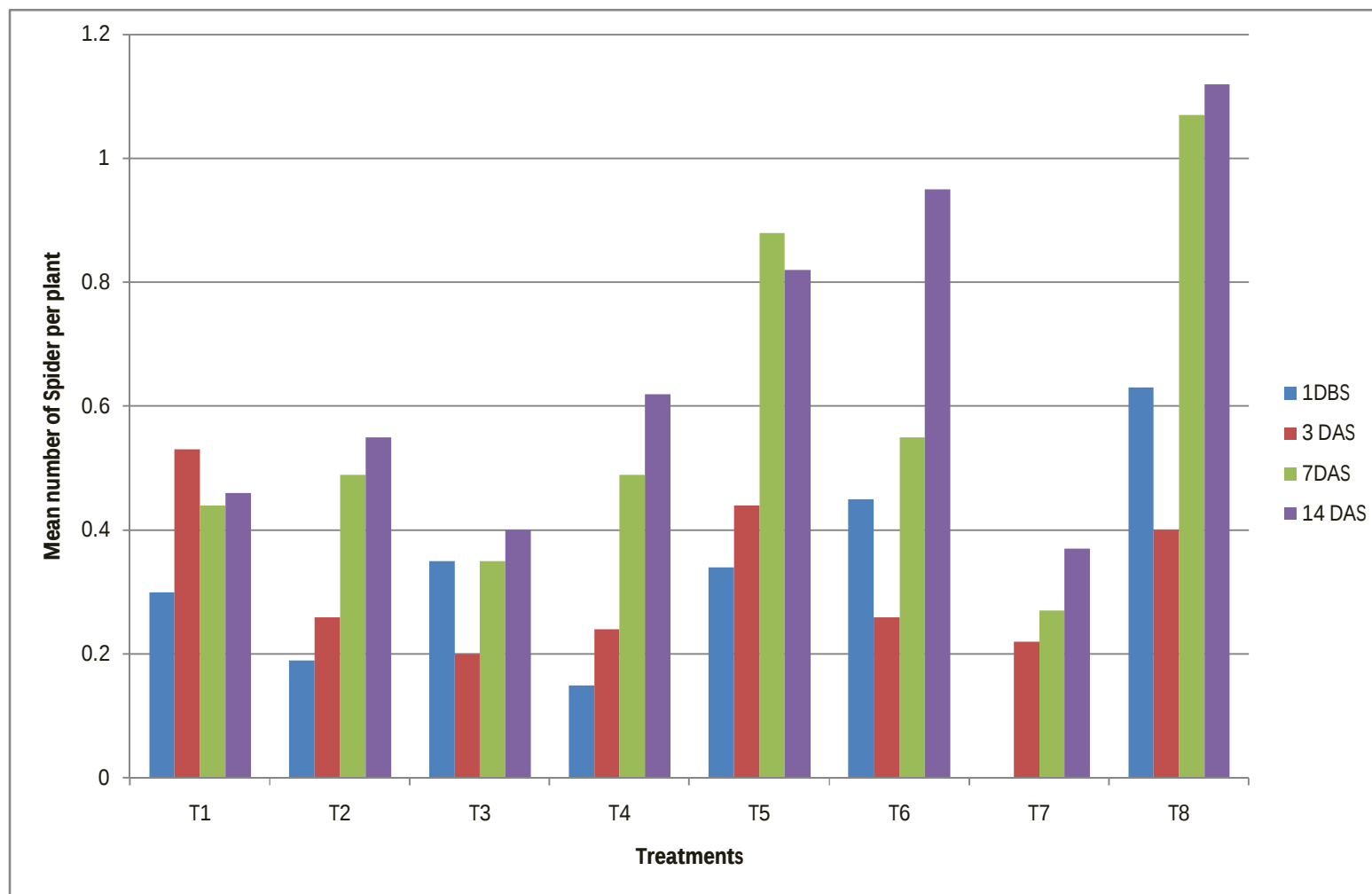


Fig : 16 Effect of different Insecticides on population of spider (third spray).

4.1.5 Effect of different insecticides on per cent pod damage and grain damage.

4.1.5.1 Percent pod damage by pod borer

Six insecticides were tested for their reaction to the infestation of pod borer complex (*H. armigera*, *M. obtuse* *M. vitrata*) showed a significant variation in respect of per cent pod damage at harvest are presented in Table No.17 and Fig 17.

Among the insecticide T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was significantly superior to reduce the pod damage by *H. armigera* (5.00%) and was at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (6.27%). followed by T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (8.61%) The next best treatment T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (11.66%), T2 acetamiprid 20SP@20 g.a.i/ha (11.94%), T1 acephate 75SP@750 g.a.i/ha,(14.16%) and T7 dimethoate 30 EC@600 g.a.i/ha (15.28%). The highest pod damage of pod borer (19.72%) was observed in untreated control.

4.1.5.2 Per cent pod damage by pod fly

The data presented in table 17 the least pod damage with *M. obtusa* was recorded with the treatment of T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (3.6 %) and which was at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (4.5%). The next best set of the treatment T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (7.4%), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (8.8%), T2 acetamiprid 20SP@20 g.a.i/ha (10.0%), T1 acephate 75SP@750 g.a.i/ha,(10.6%) and T7 dimethoate 30 EC@600 g.a.i/ha (11.7%). The highest pod damage of pod fly (18.1%) was observed in untreated control.

4.1.5.3 Per cent total pod damage by pod borer complex.

The data presented in Table 17 on the total pod damage by pod borer complex, significantly least total pod damage was recorded in the treatment of T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (8.6%) and was at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20

g.a.i/ha (10.77%). The next best set of the treatment T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (16.01%), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (20.46%), T2 acetamiprid 20SP@20 g.a.i/ha (21.94%), T1 acephate 75SP@750 g.a.i/ha,(24.76%) and T7 dimethoate 30 EC@600 g.a.i/ha (26.98%). The highest total pod damage (37.82%) was observed in untreated control. The present findings are similar with Sreekanth *et al.*, (2013) who reported that Pod damage due to pod borer, *Helicoverpa* was lowest in plots treated with flubendiamide (1.16%), chlorantraniliprole (1.26%) and spinosad (1.92%) with 88.7, 87.7 and 81.2 per cent reduction over control respectively. The untreated plot has recorded maximum pod damage of 10.22%. similarly Patel and Patel (2013) reported the Chlorantraniliprole 18.5 % SC @ 30 g a.i./ha registered the lowest pod damage due to borer and pod fly and recorded the highest yield of pigeonpea. Sreekanth *et al.*, (2014) who reported that the pod damage due to pod fly was lowest in spinosad 45% SC (10.2%), flubendiamide 480 SC (10.4%), profenophos 50% EC (10.9%) and chlorantraniliprole 20% SC (12.5%) with 76.7, 76.3, 75.1 and 71.5 per cent reduction over control (43.8%), respectively.

4.1.5.4 Per cent grain damage by pod borer

The data presented in Table 17 on the grain damage due to pod borer the significant variation in respect of per-cent grain damage of pod borer are presented in Table No.17 and Fig 17.

Among the insecticide T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was significantly superior to reduce the grain damage by *H. armigera* (2.12%) and which was similar with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (2.79%). The next best treatment T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (4.36%), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (4.76%), T2 acetamiprid 20SP@20 g.a.i/ha (5.74%), T1 acephate 75SP@750 g.a.i/ha,(7.38%) and T7 dimethoate 30 EC@600 g.a.i/ha (7.30%). The highest grain damage of pod borer (7.96%) was observed in untreated control.

4.1.5.5. Per cent grain damage by pod fly

The data presented in Table 17 the per-cent grain damage due to pod fly the least grain damage with *M. obtusa* was recorded with the treatment of T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha

>dimethoate 30 EC@600 g.a.i/ha (3.41 %) and which was at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (4.96 %) The next best T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (7.05%), T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (7.06%), T2 acetamiprid 20SP@20 g.a.i/ha (10.11%), T1 acephate 75SP@750 g.a.i/ha,(10.33%) and T7 dimethoate 30 EC@600 g.a.i/ha (12.37%). The highest grain damage of pod fly (20.99%) was observed in untreated control.

4.1.5.6 Per cent total grain damage by pod borer complex.

The data on per cent total grain damage by pod borer complex revealed that the least total grain damage was recorded with the treatment of T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha was significantly superior to reduce the total grain damage by(5.53%) and was at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (7.75%). The next best treatment T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (11.41%) , T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (11.82%), T2 acetamiprid 20SP@20 g.a.i/ha (15.85%), T1 acephate 75SP@750 g.a.i/ha (17.71%) and T7 dimethoate 30 EC@600 g.a.i/ha (19.67%). The highest total grain damage (28.95%) was observed in untreated control. Similarly Sreekanth *et al.*, (2013) who reported the chlorantraniliprole 20 SC (0.43), flubendiamide 480 SC (0.59) and spinosad 45 SC (0.85) as against untreated control plot (4.17) with 89.7, 85.9 and 79.6 per cent larval reduction over control, respectively. Pod damage due to pod borer, *Helicoverpa* was lowest in plots treated with flubendiamide (1.16%), chlorantraniliprole (1.26%) and spinosad (1.92%) with 88.7, 87.7 and 81.2 per cent reduction over control respectively. The untreated plot has recorded maximum pod damage of 10.22%.and similarly Sreekanth *et al.*, (2014) who reported that the pod damage due to podfly was lowest in spinosad 45% SC (10.2%), flubendiamide 480 SC (10.4%), profenophos 50% EC (10.9%) and chlorantraniliprole 20% SC (12.5%) with 76.7, 76.3, 75.1 and 71.5 per cent reduction over control (43.8%) respectively.

Table 17: Percent pod and grain damage by pod borer complex of Pigeonpea.

Sr.No	Name of The treatment	Percent pod damage			Percent grain damage		
		pod borer	pod fly	Total	pod borer	pod fly	Total
1	Acephate 75 SP @ 0.15 %	14.16 (21.86)	10.6 (18.91)	24.76 (24.71)	7.38 (15.65)	10.33 (18.68)	17.71 (17.71)
2	Acetamiprid 20 SP @ 0.004 %	11.94 (20.21)	10.0 (18.43)	21.94 (21.94)	5.74 (13.85)	10.11 (18.52)	15.85 (15.85)
3	Chlorantraniliprole 18.5%SC >Acephate 75SP	11.66 (19.95)	8.8 (17.16)	20.46 (20.43)	4.76 (12.58)	7.06 (15.35)	11.82 (11.82)
4	Chlorantraniliprole 18.5%SC >Acetamiprid 20SP	8.61 (16.66)	7.4 (15.62)	16.01 (15.99)	4.36 (11.98)	7.05 (15.40)	11.41 (11.41)
5	Chlorantraniliprole 18.5%SC >Indoxacarb 15.8 E C>Acetamiprid 20 SP	6.27 (14.46)	4.5 (12.15)	10.77 (10.81)	2.79 (9.59)	4.96 (12.87)	7.75 (7.76)
6	Chlorantraniliprole 18.5%SC >Flubendiamide20WG > Dimethoate 30 EC	5.00 (12.92)	3.6 (10.93)	8.6 (8.61)	2.12 (8.35)	3.41 (10.49)	5.53 (5.53)
7	Dimethoate 30 EC	15.28 (22.89)	11.7 (19.97)	26.98 (26.94)	7.30 (15.64)	12.37 (20.33)	19.67 (19.67)
8	Untreated Control	19.72 (26.35)	18.1 (25.00)	37.82 (37.77)	7.96 (16.39)	20.99 (27.25)	28.95 (28.95)
	S. E. $\pm$	1.69	1.24	2.33	0.73	1.32	1.57
	CD at 5%	5.12	3.74	7.05	2.21	4.00	4.74
	CV %	15.14	12.45	19.35	9.75	13.22	18.32

Figures of percentage in parenthesis are angular transformed values.

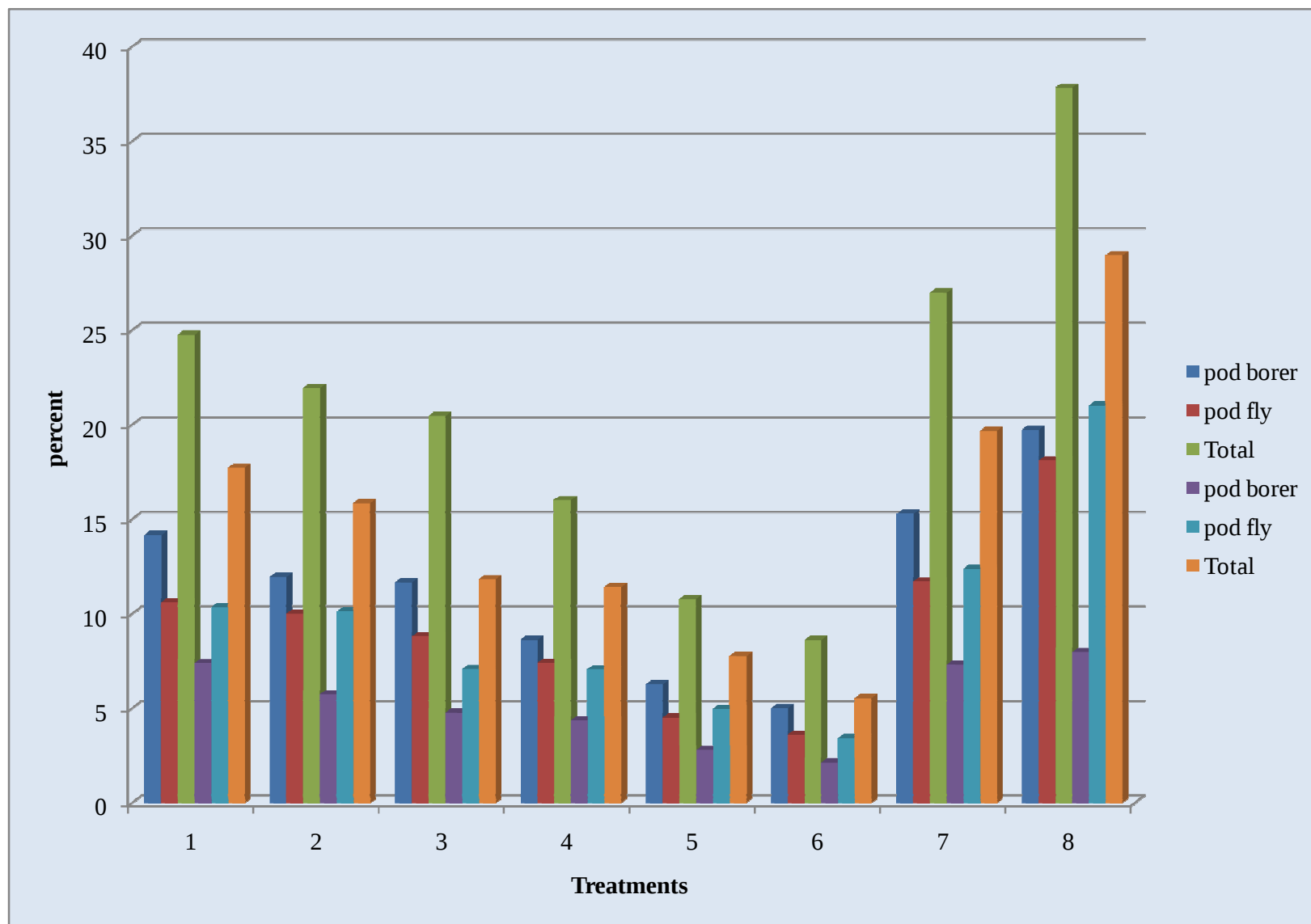


Fig: 17 Percent pod and grain damage by pod borer complex of Pigeonpea.

4.1.6 Effect of different insecticides on grain yield and incremental cost benefit ratio (ICBR) of pigeonpea pod borer complex.

4.1.6.1 Effect of different insecticides on grain yield of pigeonpea.

The results in respect of effect of different insecticides on grain yield of pigeonpea crop are presented in Table 18 and depicted in Fig. 18.

The data regarding grain yield of pigeonpea revealed that all the treatments were statistically significant in increasing grain yield over untreated control. The Grain yield of pigeonpea due to different treatments varied from 1620 to 2506 kg per hectare. The significantly highest grain yield (2506 kg per hectare) of pigeonpea was recorded in T6 chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha. and which was at par with T5 chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha was superior (2410 kg per hectare) the next T4 chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (2310 kg per hectare), followed by T3 chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (2080 kg per hectare), T2 acetamiprid 20SP@20 g.a.i/ha (1823 kg per hectare). T1 acephate 75SP@750 g.a.i/ha (1720 kg per hectare) and T7 dimethoate 30 EC@600 g.a.i/ha (1620 kg per hectare) and which was also statistically superior over control.

The present findings are similar with Sreekanth *et al.*, (2013) who reported that the yield enhancement in pigeonpea with chlorantraniliprole treated plots (686.1 kg/ha) with 127.5 per cent increase over control, followed by flubendiamide (595.8 kg/ha) and spinosad (589.0 kg/ha) with 97.6 and 95.3 per cent increase over control respectively as against the minimum yield of 301.6 kg/ha in the untreated check. Similarly Deshmukh *et al.*, (2010) reported that the yield enhancement in chickpea with treatment of flubendiamide 0.007 per cent (1850 kg/ha) followed by indoxacarb 0.0075per cent (1805 kg/ha), spinosad 0.009 per cent (1760 kg/ha) and emamectin benzoate 0.0015 per cent (1665 kg/ha).

Table 18: Effect of different insecticides on grain yield of pigeonpea.

Tr. No.	Treatments	Dosages (g.a.i/ha)	Mean grain yield kg/ ha
T ₁	Acephate 75 SP	750	1720

	@ 0.15 %		
T ₂	Acetamiprid 20 SP @ 0.004 %	20	1823
T ₃	Chlorantraniliprole 18.5%SC >Acephate 75SP	30 750	2080
T ₄	Chlorantraniliprole 18.5%SC >Acetamiprid 20SP	30 20	2310
T ₅	Chlorantraniliprole 18.5%SC >Indoxacarb 15.8 EC >Acetamiprid 20 SP	30 73 20	2410
T ₆	Chlorantraniliprole 18.5%SC >Flubendiamide20WG >Dimethoate 30 EC	30 73 600	2506
T ₇	Dimethoate 30 EC	600	1620
T ₈	Untreated Control	-	1450
S.E. ±			55
C.D at 5%			167
C.V. (%)			15.73

4.1.6.2 Effect of different insecticides on incremental cost benefit ratio (ICBR) of pigeonpea pod borer complex.

The data generated on incremental cost benefit ratio of different insecticides applied against major insect-pests of pigeonpea are tabulated in Table 19 and depicted Fig. 19. Among all the treatments, highest incremental cost benefit ratio (1:12.52) was attained by T₄ chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (1:12.52) followed by T₂ acetamiprid 20SP@20 g.a.i/ha(1:10.44), T₆chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (1:9.11), T₅ chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (1:9.01), T₃ chlorantraniliprole18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (1:6.49). T₁ acephate 75SP@750 g.a.i/ha, (1:3.5)and T₇ dimethoate 30 EC@600 g.a.i/ha (1:3.27), respectively. However, the ICBR was highest in treated spray of chlorantraniliprole > acetamiprid ,dimethoate, acephate due to less cost of insecticides as compare to the chlorantraniliprole, flubendiamide and indoxacarb.

These results are analogous to the findings Sreekanth *et al.*, (2013) reported that the results indicate that highest grain yield was recorded in chlorantraniliprole treated plots (686.1 kg/ha) with 127.5 per cent increase over control, followed by flubendiamide (595.8 kg/ha) and spinosad (589.0 kg/ha) with 97.6 and 95.3 per cent increase over control respectively as against the minimum yield of 301.6 kg/ha in the

untreated check. The cost effectiveness of chlorantraniliprole and flubendiamide was also high and very favorable with incremental cost-benefit ratios of 1: 4.64 and 1: 4.50 respectively, followed by indoxacarb (1: 3.67), emamectin benzoate (1: 3.13) and spinosad (1: 2.97).

Priyadarshini *et al.*, (2013) reported that the highest net profit was obtained from the treatment flubendiamide 480 SC at 60 g a.i. ha⁻¹ (Rs. 12,638) followed by lambda-cyhalothrin 5 EC at 25 g a.i. ha⁻¹ (Rs. 7092), indoxacarb 18.5 EC at 18.8 g a.i. ha⁻¹ (Rs. 6462.4), while lambda-cyhalothrin 5 EC at 25 g a.i. ha⁻¹ (1:7.5) recorded highest incremental cost benefit ratio followed by lambda-cyhalothrin 5 EC at 25 g a.i. ha⁻¹ (1:4.7) and quinalphos 25 EC at 250 g a.i. ha⁻¹ (1:4.4).

Table 19: Incremental cost benefit ratio (ICBR) of different insecticides used against pod borer complex of pigeonpea.

Tr. no.	Treatments	Pigeon pea yield (kg/ha)	Increase in yield over untreated control (Kg/ha)	Cost of insecticides Per litre (Rs.)	Quantity required for three sprays (ml/gm/ha)	Cost of insecticide required for three sprays (Rs. /ha)	Labour charges and rent for three sprays (Rs./ha)	Total cost (Rs./ha)	Value of additional yield over untreated control (Rs./ha)	Incremental benefit (Rs./ha)	ICBR	RANK
1	Acephate 75 SP @ 0.15 %	1720	270	640	2000	1920	1200	3120	14040	10920	1:3.5	6
2	Acetamiprid 20 SP @ 0.004 %	1823	373	1650	200	495	1200	1695	19396	17701	1:10.44	2
3	Chlorantraniliprole 18.5%SC >Acephate 75SP	2080	630	12600+ 640	150+2000	3170	1200	4370	32760	28390	1:6.49	5
4	Chlorantraniliprole 18.5%SC >Acetamiprid 20SP	2310	860	12600+ 1650	150+200	2090	1200	3290	44720	41430	1:12.52	1
5	Chlorantraniliprole 18.5%SC >Indoxacarb 15.8 EC >Acetamiprid 20 SP	2410	960	12600+ 4000+1650	150+350 +200	3785	1200	4985	49920	44935	1:9.01	4
6	Chlorantraniliprole 18.5%SC >Flubendiamide20 WG >Dimethoate 30 EC	2506	1056	12600+ 7000+290	150+250+ 2000	4230	1200	5430	54912	49482	1:9.11	3
7	Dimethoate 30 EC	1620	170	290	2000	870	1200	2070	8840	6770	1:3.27	7
8	Untreated control	1450	--	--	--	--	--	--	--			

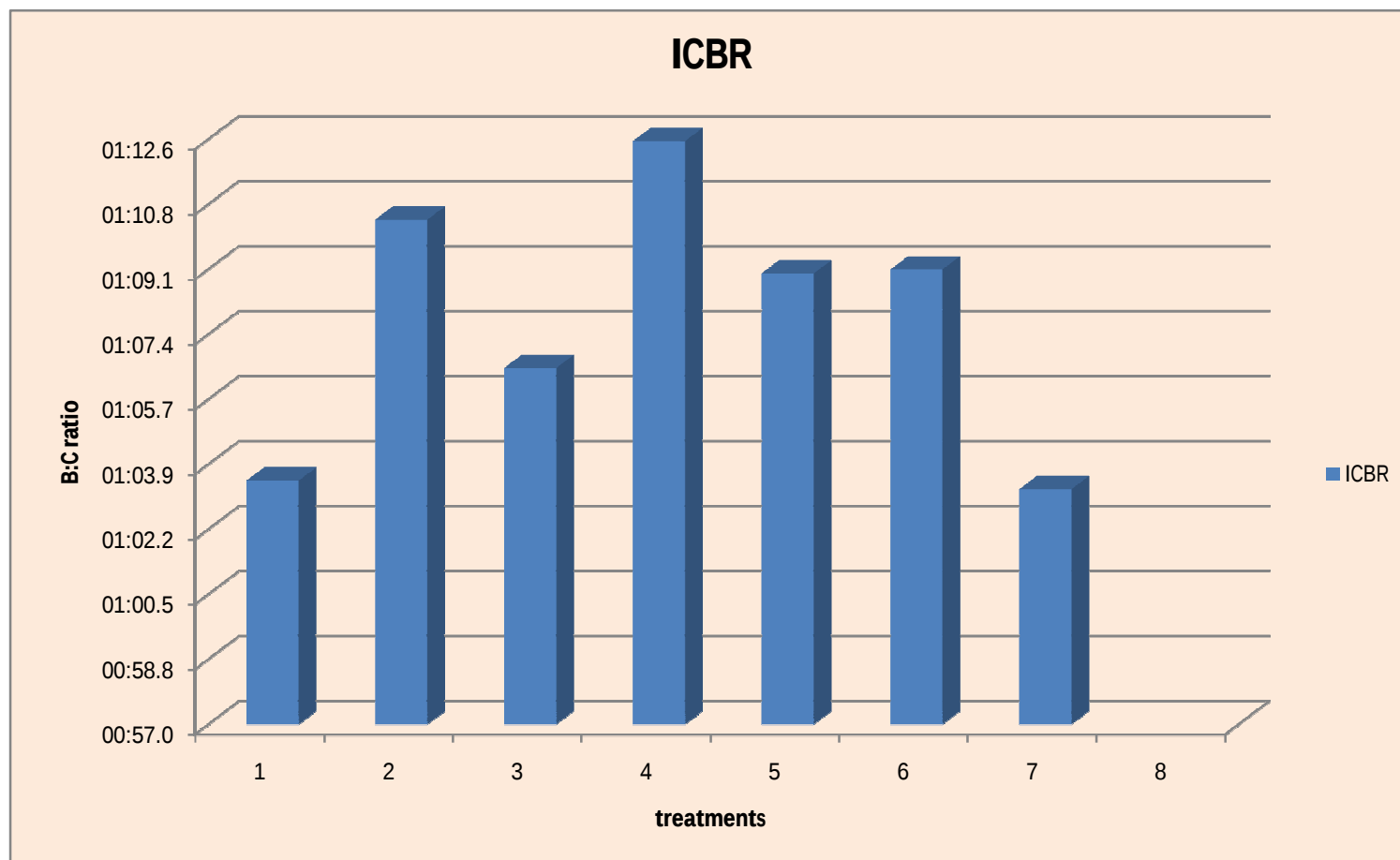


Fig: 19 Incremental cost benefit ratio (ICBR) of different insecticides used against pod borer complex of pigeonpea.

CHAPTER – V

SUMMARY AND CONCLUSION

To study, “Evaluation of sequential application of insecticides against pod borer complex of pigeon pea.” field experiment was conducted at research farm, Department of Agricultural Entomology, Agriculture Research Station Badnapur. During *Kharif* season of the year 2016-2017.

The experiment was laid out in a randomized block design (RBD) with eight treatments each replicated for three times. The experimental unit was 90x30cm size. The treatments comprised for sequential application of T₁ acephate 75SP @ 2gm/lit, T₂ acetamiprid 20SP @ 0.2gm/lit, T₃ chlorantraniliprole 18.5%SC @ 0.3ml/lit >acephate 75SP @ 2gm/lit, T₄ chlorantraniliprole 18.5%SC @ 0.3ml/lit> acetamiprid 20SP @ 0.2gm/lit, T₅ chlorantraniliprole 18.5%SC @ 0.3ml/lit> indoxacarb 15.8 EC @ 0.7ml/lit> acetamiprid 20SP @ 0.2gm/lit, T₆ chlorantraniliprole 18.5%SC @ 0.3ml/lit >flubendiamide20WG @ 0.5 gm/lit > dimethoate 30 EC 1ml/lit, T₇ dimethoate 30 EC 1ml/lit and untreated control.

The first application of insecticides was done based on economic threshold levels of pod borer complex. Observation were recorded on the population of pod borer, spotted pod borer, plume moth, and pod fly. Also observation some natural enemies like lady bird beetle, and spider. Were also recorded Incremental Cost Benefit Ratio (ICBR) of insecticides was worked out. The data in each of these categories were analyzed separately and the results obtained are summarized here under.

5.1: To evaluate the sequential application of insecticides against pod borer complex of pigeon pea.

5.2: To study the bio-safety of different insecticides against natural enemies.

5.3: To work out the yield and incremental cost benefit ratio.

5.1: To evaluate the sequential application of insecticides against pod borer complex of pigeon pea.

In field testing of sequential application of insecticides, the treatments T₆ chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha, T₅ chlorantraniliprole 18.5%SC@30 g.a.i/ha

>indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha, T₄ chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha were found effective in suppressing overall pod borer complex pod borer (*H armigera*), spotted pod borer (*M vitrata*), plume moth (*E atomosa*), pod fly (*M obtusa*). population on pigeonpea and were at par with each other.

5.2 Effect of insecticides on natural enemies.

In field testing on sequential application of insecticides, the treatments T₆ chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha followed by T₅ chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha and T₄ chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha were found less effective against natural enemies and were comparatively safer to the natural enemies of pod borer complex of pigeonpea.

The results indicated that among all insecticides treatments T₆ chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha followed by T₅ chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha and T₄ chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha were found less effective on lady bird beetle and spider population after all spray of insecticides.

5.3 yield and Incremental Cost Benefit Ratio (ICBR) of newer insecticides

The results revealed that all the insecticidal treatment were significantly superior over untreated control. The highest pigeonpea yield was recorded in plots treated with T₆ chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (2506 kg/ha) followed by T₅ chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (2410 kg/ha), T₄ chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (2310 kg/ha), T₃ chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (2080 kg/ha), T₂ acetamiprid 20SP@20 g.a.i/ha (1823 kg/ha), T₁ acephate 75SP@750 g.a.i/ha (1720 kg/ha), T₇ dimethoate 30 EC@600 g.a.i/ha (1620 kg/ha) and The lowest yield obtained from untreated plot (1450 kg/ha). It was found that highest benefit cost ratio was obtained in T₄ chlorantraniliprole 18.5%SC@30 g.a.i/ha >acetamiprid 20SP@20 g.a.i/ha (1:12.52)

followed by T₂ acetamiprid 20SP@20 g.a.i/ha (1:10.44), T₆ chlorantraniliprole 18.5%SC @30 g.a.i/ha >flubendiamide20WG@73 g.a.i/ha >dimethoate 30 EC@600 g.a.i/ha (1:9.11), T₅ chlorantraniliprole 18.5%SC@30 g.a.i/ha >indoxacarb 15.8 EC@73 g.a.i/ha >acetamiprid 20 SP@20 g.a.i/ha (1:9.01), T₃ chlorantraniliprole 18.5%SC @30 g.a.i/ha>acephate 75SP@750 g.a.i/ha (1:6.49), T₁ acephate 75SP@750 g.a.i/ha (1:3.5), and lowest benefit cost ratio T₇ dimethoate 30 EC@600 g.a.i/ha (1:3.27) .

Conclusions

The treatments where three sequential application of insecticides sprays as chlorantraniliprole followed by flubendiamide and dimethoate were found significantly effective treatment for minimum population of pod borer, plume moth, spotted pod borer and pod fly at 3,7,14 days after spray followed by treatment chlorantraniliprole followed by indoxacarb and acetamiprid which was found significantly at par with each other.in respect of low pod borer and higher grain yield.

However, all the treatments were found statistically non significant in respect of predator population on plant i.e. Lady bird beetle and spider. at 3,7 and 14 days after spray.

The highest pigeonpea grain yield was recorded in plots treated with chlorantraniliprole >flubendiamide>dimethoate (2506 kg/ha) compare to all other treatments. an experimental results on Incremental Cost Benefit Ratio shows that highest benefit cost ratio was obtained in chlorantraniliprole> acetamiprid (1:12.52).

LITERATURE CITED

- Acharya S., Mishra H. P. and Dash D. 2002. Efficiency of insecticides against okra jassid, *Amrasca biguttula biguttula* Ishida. *Ann. Pl. Prot. Sci.* 10(2): 230-232.
- Adsure P. Savita and Mohite Pandurang B. 2014. Efficacy of Newer Molecules of Insecticides against Gram Pod Borer, *Helicoverpa armigera* (Hub.) on Chickpea. **4** (12).
- AL-Kherb W.A. 2011. Field Efficacy of Some Neonicotinoid Insecticides on Whitefly *Bemisia tabaci* (Homoptera: Aleyrodidae) and its Natural Enemies in Cucumber and Tomato Plants in Al-qassim Region, KSA. *J. Entomol.*, 8 (5): 429-439.
- Ameta O. P. and Ajay Kumar. 2008. Efficacy of flubendiamide against *Helicoverpa armigera* (Hubner) and *Spodoptera litura* (Fab.) in chilli. Department of Entomology, R.C.A.M.P.A.T., Udaipur -313 001. *Pestology.*, **32**(5): 26-29.
- Ameta O. P., Sharma, U. S., and Jain, H. K. (2010a). Relative efficacy of flubendiamide 480SC against *Helicoverpa armigera* (Hubner) in chickpea. Department of Entomology, R.C.A., Udaipur. *Pestology.*, **34**(11). PP: 31-35.
- Ameta O.P., Sharma U.S. and Jain H.K. (2010) Relative efficacy of flubendiamide 480 SC against *Helicoverpa armigera* (Hubner) in chickpea. *Pestology*, **34**(11):31-35.
- Ameta O.P., Sharma U.S. and Jeengar K.I. (2011b) Efficacy of flubendiamide 480 SC against pod borer, *Helicoverpa armigera* (Hubner) and *Maruca testulalis* (L) in pigeonpea. *Indian Journal of Entomology*, **73**(3):191-195.
- Ankali S.M., Jadhav Y.T, Jadhav K.A. and Barkade D.P. (2011). Study of relative toxicity of synthetic insecticides and biopesticides to *Maruca vitrata* on pigeonpea. *International Journal of Plant Protection*, Vol. **4** No. 1 : 156-157.
- Anonymous 2005. Annual Progress Report of All India Coordinated Research Project on Pigeonpea, Indian Institute of Pulses Research, Kanpur.

- Anonymous 2016. Annual report, All India Co-ordinated Research Project on pigeonpea. *Indian Council of agricultural and Research*.
- Anonymous 2014. Annual Progress Report of All India Coordinated Research Project on Pigeonpea, Indian Institute of Pulses Research, Kanpur.
- Anonymous¹ (2014a). Annual report, Project Co-ordinators Report Annual Group Meet. All India Co-ordinated Research Project on Pigeonpea. (Indian Council of Agricultural Research).
- Anonymous² (2014b). Annual report, All India Co-ordinated Research Project on Pigeonpea. (Indian Council of Agricultural Research).
- Anonymous³ 2004. Area, production and yield of tur (arhar) from 1950-51 to 2003-04 along with percentage coverage under irrigation. *Statistics at a glance*, pp : 63.
- Anonymous⁴ 2011. Area, production and productivity of major pulses. www.agropedia.com.
- Anonymous⁵ 2013. Economics survey of Maharashtra 2012-13. Directorate of Economics and Statistics, Planning Department. Government of Maharashtra, Mumbai. PP: 84.
- Babariya P. M. and Kabaria B. B. and Patel, V. N. and Joshi M. D. 2010. Chemical control of gram pod borer, *H. armigera* Hubner infesting pigeonpea. *Legume Research*, **33**(3): pp.224-226.
- Bhuvaneswari K. and Balagurunathan R. 2002. Pod borer complex of pigeonpea in Tamil Nadu. *Insect Environ.*, **8**(4):160-161.
- Chuadhary H. R., Mathur A. K., Sharma K. P. and Girdhar Gopal 2003, Efficacy of some insecticide against *H. armigera* Hubner, *Indian J. Appl. Ent.*, **17**(1): 59-61.
- Dabhi M.V., Patel H.M., Bharpoda T.M. and Jhala R.C.2015. Bio-efficacy of indoxacarb 15 EC against pod borer, *Helicoverpa armigera* (Hubner) hardwick infesting pigeonpea. *International Journal of plant rotection volume* **8**(1): 65-68.
- Deshmukh S. G., Sureja B. V., Jethva D. M. and Chatar V. P. 2010. Field efficacy of different insecticides against *Helicoverpa armigera* (Hubner) infesting chickpea. Department of Agricultural Entomology, Junagadh

- Agricultural University, Junagadh-362 001. India. *Legumes Res.*, **33**(4): 269-273.
- Dhawan A.K., Singh R., Singh K. and Sharma M. 2009. Efficacy of chlorantraniliprole against bollworm complex on cotton. *J. Insect Sci., (Ludhiana)*, **22**(3): 248-253.
- Dodia DA, Prajapati BG and Acharya S. 2009. Efficacy of insecticides against gram pod borer, *Helicoverpa armigera* Hardwick, infesting pigeonpea. *Journal of food legumes*. **22**(2): 144-145.
- Gadhiya H.A. Borad P.K. and Bhut J.B. 2014. Effectiveness of synthetic insecticides against *Helicoverpa armigera* (Hubner) Hardwick and *Spodoptera litura* (Fabricius) infesting Groundnut. *An International of quarterly Journal of life sciences* **9**(1): 23-26.
- Gomez K.A. & Gomez A.A. 1984. Statistical procedures for agricultural research. John Wiley sons, New York, 207-215 pp.
- Gupta M. P. and Pathak R. K. 2009. Bioefficacy of neem products and insecticides against the incidence of white fly and pod borer in black gram. *Natural Product Radiance*, **8**(2) PP. 133-136.
- Jadhav R. P., Mundhe D. R., Bhosle B. B. and Yadav G. A. 2009. Bioefficacy of new insecticide acetamipride 20 SP and indoxacarb 14.5 SC against bollworm complex of cotton. Department of Entomology, Marathwada Agricultural University, Parbhani 431 402, M.S., India. *Pesticide Research Journal*. **21**(2): 150-154.
- Jagadeesh Babu C.S. and Mallicarjun 2012. Evaluation of different insecticides and bio-pesticides for control of pigeonpea pod borer (*Helicoverpa armigera* Hubner). *International Journal of plant protection*. **5**(2):272-274.
- Karmakar K. and Patra Sandip 2015. Bio-efficacy of some new insecticide molecules against pod borer complex of Red gram. *Legume Research*, **38**(2):253-259.
- Khalid Ahmed* and Prasad N.V.V.S.D. 2011. Evaluation of indoxacarb 15% SC against fruit borers in chillies. *Pestology.*, **35**(10): 46-49.
- Khan H. K. and Narayanappa, E. 1993. Management of tur pod borer in the red gram production demonstration. *Pl. Prot. Bull.*, **45**(2/3): 38-39.

- Kumar Sunil G.V. and Sarada O. 2015. Field efficacy and economics of some new insecticide molecules against lepidopteran caterpillars in chickpea. *Current Biotica* **9**:2153-158.
- Khorasiya S.G., Vyas H.J., Jetha D.M., and Joshi P.H. 2014. Field efficacy of *Helicoverpa armigera* (Hübner) hardwick on pigeonpea. *International Journal of plant protection* **7**(2) 325-329.
- Lal S. S., Yadav, C. P. and Ahmad, P. 1997. Insect-pests of short duration pigeonpea-a review. *Plant Prot. Bull.*, **49**(1/4): 25-32.
- Mishra Mukesh K., Singh Rudra P., Ali Shamshad. 2012. Chemical control and avoidable yield losses of Pigeon pea due to insect pests. *Annals of Plant Protection Sciences*. **20**(2):306-309.
- Narasimhamurthy G.M. and Keval Ram. 2012. Efficacy of some insecticides and biopesticides against pod borer, *Helicoverpa armigera* (Hubner) in long duration pigeonpea. *New Agriculturist*, **23**(2):149-153.
- Pappu B. K., Srivastava C. P. and Sharma R. P. 2010. Bioefficacy of some newer insecticides against pest complex on short duration pigeonpea. Department of Entomology and Agril. Zoology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, U.P. - 221 005. *Pestology.*, **34**(10): 30-32.
- Patel S.A. and Patel R.K. 2013. Bio-efficacy of Newer insecticides against pod borer complex of pigeonpea [*Cajanus cajan* (L.) Millspaugh]. *AGRES-An International e-Journal*, **2**(3): 398-404.
- Priyadarshini G., Narendra Reddy C. and Reddy Jagdishwar. 2013. Bioefficacy of selective insecticides against lepidopteron pod borers in pigeonpea. Department of Entomology, College of Agriculture, Rajendranagar, Acharya N. G. Ranga Agricultural University, Hyderabad-500030, Andhra Pradesh, India, *Indian Journal of Plant Protection.*, **41**(1): 6-10.
- Raghvani¹ B. R. and Poshia² V. K. 2006. Field efficacy of newer molecules of insecticides against pod borer (*Helicoverpa armigera* Hub.) in chickpea. ¹Associate Research Scientist (Ento.) and ²Research

- Scientist (Chickpea) Pulses Research Station, Junagadh Agricultural University, Junagadh-362 001, Gujarat, India. *Pestology* ., **30**(4): 18-20.
- Razaq M., Suhail, A., Aslam, M., Arif, M.J., Saleem, M.A. and Muhammad ahamadkhan. 2005. Evaluation of new chemicals and conventional insecticides against *Helicoverpa armigera* (Hubner) on cotton at Multan (Pakistan). *Pak. Entomol.*, **27**(1): 71-73.
- Ramnath S., Chitra, K. and Uthamasamy, S. 1992. Behavioural response of *Helicoverpa armigera* (Hubner) to certain host plants. *J. Insect Sci.*, **4**(2):174-175.
- Randhawa H.S. and Saini M.K. 2015. Efficacy of different insecticides against pod borer, (*Maruca vitrata* Geyer) in pigeonpea. *Legume Research.*, **38** (5):687-690.
- Rangarao G. V. and Shanower T. G. 1999. Identification and management of pigeonpea and chickpea insect-pests in Asia. Information Bulletin no.57. *International Crops Research Institute for the Semi-Arid Tropics.*, PP: 6-7.
- Sahoo B. K. and Senapati B. 2000. Efficacy and economics of synthetic insecticides and plant products for the control of pod borer incidence in pigeonpea. *Indian J. Ent.*, **62**(4): 346-352.
- Sambathkumar S., Durairaj C., Ganapathy N and Mohankumar S. 2015. Field evaluation of newer insecticide molecules and botanicals against pod borers of red gram. *An International Journal* **38** (2): 260 – 267.
- Satpute N. S. and Barkhade U. P. 2012. Evaluation of rynaxypyr 20 SC against pigeonpea pod borer complex. Department of Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola-444 104. Maharashtra, India. *Journal of Food Legumes.*, **25**(2): 162-163.
- Seal D.R., Schuster D.J. and Klassen W. 2007. Comparative Effectiveness of New Insecticides in Controlling Army worms (Lepidoptera:Noctuidae) and Leaf miners (Diptera: Agromyzidae) on Tomato. *Proc. Fla. State Hort. Soc.*, **120**:170-177.

- Singh Y. 2012. Studies on effect of cultivars date of sowing and insecticides on development and management strategies of *Helicoverpa armigera* in chickpea. M.Sc. (Ag.) Thesis submitted to IGKV, Raipur.
- Sunitha V. Vijaya Lakshmi K. and Ranga Rao G.V. 2008. Laboratory evaluation of certain insecticides against pigeonpea pod borer, *Maruca vitrata*. *Journal of Food Legumes* **21**(2):137-139.
- Sharma H. C., 2001. Cotton bollworm/legume pod borer, *Helicoverpa armigera*. Biology and management. Crop Protection Compendium. CAB International, Wallingford.
- Sharma O. P., Bhosle B. B., Kamble K. R., Bhede B. V. and Seeras N. R. 2011, Management of pigeonpea borers with special reference to pod fly *Melanagromyza obtusa*. *Indian Journal of Agricultural Sciences*., **81**(6):539-543.
- Shrivastava Nikhil, Odak S. C., Das S. B. and Goswami H. 1993. Studies on susceptibility of pigeonpea cultivars to some pod infesting insects. *JNKVV Res. J.*, **27**(1): 143-147.
- Sidde Gowda D. K., Yelshetty Suhas., Patil, B. V. and Gopali, J. B. 2006. Field evaluation of newer insecticides against gram pod borer *Helicoverpa armigera* (Hubner). Agricultural Research Station, Gulbarga- 585 101, College of Agriculture, Raichur-584 101. *Pestology*., **30**(4).
- Singh A. K. 2014. Evaluation of new molecule of insecticides against pod fly (*Melanagromyza obtusa*) of pigeon pea. *SAARC J. Agri.*, **12**(1): 89-95.
- Singh S. S. and Yadav Sujit K. 2005. Bioefficacy of modern insecticides, biopesticides and their combination against pod borers in pigeonpea. *Indian Journal of Entomology*., **67**(2): 133-136.
- Singh V. and Verma P. C. 2006. Management of pod borer (*Helicoverpa armigera* Hub.) in chickpea with newer chemicals. Agricultural Research Station, Rajasthan Agricultural University, Sriganganagar, Rajasthan, India. *Pestology*., **30**(6) June 2006. PP: 36-38.
- Sinha N. M., Yadav R. P. and Kumar A. 1977. Evaluation of some insecticides for the control of plume moth (*Exelastis atomosa* Walshe) and Pod fly

(*Melanagromyza obtusa* M.) on red gram (*Cajanus cajan* L.).

Pesticides., **11**: 29-30.

- Sreekanth M., Lakshmi M. S. M. and KoteswaraRao Y. 2013. Bio-efficacy and economics of certain new insecticides against gram pod borer, *Helicoverpa armigera* (Hubner) infesting pigeonpea (*Cajanus cajan* L.). *International Journal of Plant, Animal and Environmental Sciences*. **4**(1):11-15.
- Sreekanth M., Lakshmi M. S. M. and KoteswaraRao Y. 2014. Efficacy of novel insecticides to control podfly *melanagromyza obtuse* affecting pigeonpea (*Cajanus cajan* L.). *Journal of Plant and Pest Science*. **1**(1): 35-38.
- Sreekanth M., Lakshmi M. S. M. and KoteswaraRao Y. 2015a. Efficacy of Different Insecticides against Legume Pod Borer, *Maruca vitrata* (Geyer) on Pigeonpea (*Cajanus cajan* L.). *IJISET - International Journal of Innovative Science, Engineering & Technology*, Vol2.
- Sreekanth M., Lakshmi M. S. M. and KoteswaraRao Y. 2015b. Evaluation of Certain Insecticides against Gram Pod Borer, *Helicoverpa armigera* (Hubner) Infesting Pigeonpea (*Cajanus cajan* L.). *International Journal of pure & applied Bioscience* **3**(3):280-283.
- Srinivasan T. and Dhurairaj, C. 2007. Newer insecticides against pod borer complex on pigeonpea with special reference to *Helicoverpa armigera* and *Melanagromyza obtusa*. Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India. *Indian Journal of Plant Protection.*, **35**(1), 47-49.
- Srujana Y. and Keval Ram 2013. Effect of newer insecticides against pod fly, *Melanagromyza obtusa* (Malloch) on long duration pigeon pea. *IOSR Journal of Agriculture and veterinary science (IOSR-JAVS)* **5**(4):25-27.
- Suganthi A., Jayakumar* R. and Kuttalam S. 2006. Bioefficacy and phytotoxicity of pyridalyl 10 EC against pod borer, *Helicoverpa armigera* (Hb.) (Noctuidae: Lepidoptera) on pigeonpea. Department of Entomology, *Department of Soil Science and Agricultural Chemistry, Tamil Nadu

Agricultural University, Coimbatore – 641 003, India. *Pestology*.
30(7): 17-20.

- Thilagam P., Sivasubramanian S. and Kuttalam, S. 2011. Impact of flubendiamide on the important natural enemies in cotton ecosystem. *Pestology*, **35** (2): 45-49.
- Tamboli N. D. and Lolage G. R. 2008. Bio-efficacy of newer insecticides against pod borer, *Helicoverpa armigera* Hub (Noctuidae: Lepidoptera) on pigeonpea. *Pestology*, **32**(10): 29-32.
- Umbarkar P.S. and Parsana G.J. 2014. Field efficacy of different insecticides against spotted pod borer, *maruca vitrata* (Geyer) infesting Green gram. *Jr. of Industrial pollution control* **30**(2):227-230.
- Wadaskar R. M., Bhalkare S. K. and Patil A. N. 2013. Field efficacy of newer insecticides against pod borer complex of pigeonpea. *Pulses Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola-444 104, Maharashtra, India. Journal of Food Legumes.*, **26**(1&2): 62-66.
- Yadav L. S. and Chaudhary J. P. 1993. Estimation of losses due to pod borer in pigeonpea. *Indian J. Ent.*, **55**(3-4):287.
- Yadav N. K. and Singh P. S. 2014, Bio-efficacy of chemical insecticides against spotted pod borer, *Maruca testulalis* (Geyer) on cowpea. Department of Entomology and Agricultural Zoology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India. *International Journal of Agriculture, Enviroment and Biotechnology*. **7**(1): 187-190.

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